te technical note techn

Traffic Information Service (TIS) Developmental /Operational Test and Evaluation (DT&E and OT&E) Final Test Report

Michael McNeil

19980806 012

June 1998

DOT/FAA/CT-TN98/10

Document is on file at the William J. Hughes Technical Center Library, Atlantic City International Airport, NJ 08405

U.S. Department of Transportation
Federal Aviation Administration

William J. Hughes Technical Center
Atlantic City International Airport, NJ 08405

NOTICE

Technical Report Documentation Page

1. Report No. DOT/FAA/CT-TN98/10	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Traffic Information Service (TIS) Developmental/Operational Test and Evaluation (DT&E and OT&E) Final Test Report		5. Report Date June 1998
		6. Performing Organization Code
7. Author(s) Michael McNeil; Robert Sharkey, DI		8. Performing Organization Report No. DOT/FAA/CT-TN98/10
9. Performing Organization Name and Address U.S. Department of Transportation Federal Aviation Administration William J. Hughes Technical Center Atlantic City International Airport, NJ 08405		10. Work Unit No. (TRAIS)
		11. Contract or Grant No.
12. Sponsoring Agency Name and Address U.S. Department of Transportation Federal Aviation Administration William J. Hughes Technical Center Atlantic City International Airport, NJ 08405		13. Type of Report and Period Covered Technical Note
		14. Sponsoring Agency Code
15. Supplementary Notes		

16. Abstract

The Federal Aviation Administration (FAA) Traffic Information Service (TIS) Developmental Test and Evaluation (DT&E) and Operational Test and Evaluation (OT&E) Final Test Report is prepared by the Mode Select (Mode S) Test Group of the Surveillance Branch ACT-310. It provides the detailed analysis, results, the final conclusions, and recommendations drawn from the DT&E and OT&E of the TIS data link service for the Mode S Beacon Radar System.

The purpose of the TIS data link function is intended to improve the safety and efficiency of "see-and-avoid" flight by providing automatic display to the pilot of nearby traffic and warnings of any potentially threatening conditions. The source of TIS information is the file of aircraft tracks maintained by the ground Mode S sensor providing coverage for a region of airspace.

17. Key Words	18. Distribution Statement
Traffic Information Service (TIS) Developmental Test and Evaluation (DT&E) Operational Test and Evaluation (OT&E) Traffic Alert and Collision Avoidance System (TCAS)	Document is on file at the William J. Hughes Technical Center Library, Atlantic City International Airport, NJ 08405

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	145	

Form DOT F 1700.7 (8-72)

Reproduction of completed page authorized

ACKNOWLEDGEMENTS

The execution of the Traffic Information Service (TIS) Developmental / Operational Test and Evaluation effort was the result of many months of planning, cooperation, and support. The Mode S Department of the Surveillance Branch, ACT-310 wishes to acknowledge the following individuals, groups, corporations, and facilities for providing their expertise, resources, and personnel towards the successful accomplish of this project.

Mode S Program Office
Vince Chu
Tom Prevost

FAA William J. Hughes Technical Center

ACT-310
Mike McNeil
Ed Dolecki
Jean Evans
Bob Sharkey
Jeff Wright

ACT-350
Al Rehmann
Peter Muraca
Rick Olson

ACT-370
Tom Grygotis
Theos McKinney
Keith Behl
Mark Ehrhart
Armando Gaetano
John Geyser
Ken Johnson
Larry VanHoy

MIT/Lincoln Laboratory
Jonathan Bernays
Mary Collins
Bob Grapple

ARCON
Nyles Barnert

Lockeed Martin
Ralph Pascal

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

EXECUTIVE SUMMARY

The Traffic Information Service (TIS) is a Mode Select (Mode S) Data Link service that delivers automatic traffic advisories to pilots. The goal of TIS is to provide an affordable means to assist the general aviation (GA) pilot in visual acquisition of surrounding air traffic. The service is automated and functions independently from air traffic controllers. The alert messages are relayed to the client aircraft via the built-in data link capability. The system does not require any changes in the equipage of intruder aircraft.

The introduction of TIS (into the Mode S baseline) added a total of 380 new requirements to be verified. Verification of these TIS requirements was split into two major test categories, Developmental Test and Evaluation (DT&E) and Operational Test and Evaluation (OT&E). Testing of these new requirements was conducted using three methods: Software Code Inspections, Test Scenarios (simulated targets), and Live Aircraft Flights. The pre-existing Mode S functionality was verified using the standard Mode S Release Qualification Test (RQT). Testing of the Data Link channel capacity was accomplished via a demonstration during the live flights. Central Processing Unit (CPU) utilization tests were conducted to determine a recommendation for setting the "TIS Maximum Aircraft Supported" Site Adaptable Parameter (SAP) value.

The formal combined DT&E/OT&E of the Traffic Information Service (TIS) software was conducted at the Federal Aviation Administration (FAA) William J. Hughes Technical Center by the Surveillance Branch, ACT-310, from July 14, 1997, through September 16, 1997.

Overall results of the formal testing are very good. All of the Software Code Inspection test cases were successfully verified. The scenario testing revealed no major problems, and only three minor, low frequency problems were identified; (1) self-alerts, (2) invalid altitude, and (3) a tracking anomaly. The first two minor problems are due to inaccuracies in the Mode S surveillance data, and the third (while within specification) could be misleading to a pilot. The live flight tests revealed the same three minor anomalies, with no other problems. The regression testing and RQT were successfully completed. The CPU Utilization testing indicated that the maximum client SAP should be set to 100. The Data Link Bandwidth test demonstrated ample channel capacity while running in TIS mode.

In conclusion, after successful completion of formal DT&E/OT&E testing, in-depth data analysis, and evaluation, the TIS software has been found to function according to specifications for all measured parameters. The addition of the TIS data link services appear to have no adverse effect on the Mode S sensor operation or performance. The Mode S data link capabilities function properly providing TIS alerts and status messages in a timely manner.

Based on the above findings, ACT-310 recommends that TIS be conditionally approved for national deployment contingent upon the following:

1. The Aeronautical Information Manual (AIM) and all other applicable user documentation be revised to thoroughly document the known problems (self-alert, invalid altitude, and tracking anomalies).
2. This version of TIS is only fielded in terminal sensor configurations.

1. INTRODUCTION.

The formal Developmental Test and Evaluation (DT&E) and Operational Test and Evaluation (OT&E) of the Traffic Information Service (TIS) software was conducted at the Federal Aviation Administration (FAA) William J. Hughes Technical Center by the Surveillance Branch, ACT-310, from July 14, 1997, through September 16, 1997. The following sections of this document will serve as the Final Test Report for that test effort.

1.1 PURPOSE.

The primary purpose of this report is to provide the detailed analysis, results, the final conclusions, and recommendations drawn from the DT&E and the OT&E of the TIS data link service for the Mode Select (Mode S) beacon radar system.

1.2 SCOPE.

This report contains an evaluation of the performance of the TIS data link function, along with an assessment of impact to the current system operation. The test was a technical evaluation and a verification of operational specifications. Included within this report is a Test Verification Requirements Traceability Matrix (TVRTM) which identifies all the requirements that were verified, including a reference to the test phase and report paragraph number in which that verification was accomplished. In areas where TIS performed at less than the expected levels there was a detailed analysis conducted to determine the cause for the deficiency.

Additional test events, not defined in the test plan (at the request of Massachusetts Institute of Technology Lincoln Labs (MITLL)), were conducted and are reported here. A Mode S Data Link channel capacity (bandwidth) Demonstration was conducted to show that TIS did not significantly impact the Mode S data link channel. Also, "Central Processor Unit (CPU) Utilization Tests" were conducted to determine a recommendation for setting the "TIS Maximum Aircraft Supported" Site Adaptable Parameter (SAP) value.

The avionics portion of the TIS system, which includes the Mode S Transponders, Airborne Data Link Processor (ADLP) and TIS displays were not evaluated as part of this test and are not reported on here. They were merely used as a test tool to collect data from (uplink messages), and send data to (downlink messages) the Mode S sensor. Previous testing of the ADLP and TIS displays is documented in the Mode S Data Link Applications, Field Demonstration Operational Test and Evaluation Final Report, September 27, 1996, and A Field Evaluation of Data Link Flight Information Services for General Aviation Pilots, February 1997.

2. REFERENCE DOCUMENTS.

This section contains a list of all reference documents used in the development of this test report.

1. Appendix XIII of Mode Select Beacon System Sensor Specification, FAA-E- 2716, Traffic Information Service (TIS) Specification, Terminal Sensor Configuration, Revision 3.1, October 8, 1996

2. Requirements Document for the Traffic Information System (Rev.2.1), April 25, 1997

3. Minimum Operational Performance Standards (MOPS) for Traffic Information Service (TIS) Data Link Communications, April 2, 1997

4. Software Detailed Design Document for the Traffic Information System (Rev.2), June 23, 1997

5. Mode Select Beacon System (Mode S) Traffic Information Service (TIS) Developmental Test and Evaluation (DT&E) and Operational Test and Evaluation (OT&E) System Test Plan, July 1997 (Final)

6. Mode Select Beacon System (Mode S) Traffic Information Service (TIS) Developmental Test and Evaluation (DT&E) and Operational Test and Evaluation (OT&E) Code Inspection Test Procedure, July 1997 (Draft)

7. Mode Select Beacon System (Mode S) Traffic Information Service (TIS) Developmental Test and Evaluation (DT&E) and Operational Test and Evaluation (OT&E) Test Procedure for Scenario Data Collection, July 1997 (Final)

8. Mode Select Beacon System (Mode S) Traffic Information Service (TIS) Developmental Test and Evaluation (DT&E) and Operational Test and Evaluation (OT&E) Test Procedure for Live Flight Data Collection, July 1997 (Final)

9. Traffic Information Service (TIS) Developmental / Operational Test and Evaluation (DT&E and OT&E) Quick Look Report, October 6, 1997

10. Aeronautical Information Manual (AIM), Official Guide to Basic Flight Information and ATC Procedures

11. Federal Aviation Administration (FAA) National Airspace System (NAS) Test and Evaluation Policy and Guidance, July 18, 1997

12. Lincoln Laboratory Flight Test Results for Traffic Information Service (TIS) Operational Test And Evaluation Report # "42PM-Data-Link-0012" dated September 10, 1997

13. Mode S Data Link Applications, Traffic Information Service (TIS) Graphical Weather Service (GWS) Text Weather Service (TWS), Field Demonstration Operational Test and Evaluation Final Report, September 27, 1996

14. A Field Evaluation of Data Link Flight Information Services for General Aviation Pilots, DOT/FAA/CT-97/3, February 1997.

3. SYSTEM DESCRIPTION.

The following sections briefly summarize the system mission and functions, test configuration, and NAS interfaces.

3.1 MISSION REVIEW.

A primary flight task for all pilots is to maintain awareness of nearby air traffic by maintaining a constant visual scan (whenever meteorological conditions permit). If traffic is sighted, the pilot must first assess the threat posed by the intruder aircraft then, if necessary, maneuver to avoid the other aircraft. This strategy for collision avoidance is termed "see-and-avoid." The effectiveness of see-and-avoid depends on the ability of the pilot to visually acquire the intruder aircraft early enough in the encounter to allow for threat assessment and avoidance.

The TIS data link function is intended to improve the safety and efficiency of "see-and-avoid" flight by providing automatic display to the pilot of nearby traffic and warnings of any potentially threatening conditions. The source of TIS information is the file of aircraft tracks maintained by the ground Mode S sensor providing coverage for a region of airspace. A diagram of the functional elements of TIS is shown in figure 3.1-1 below.

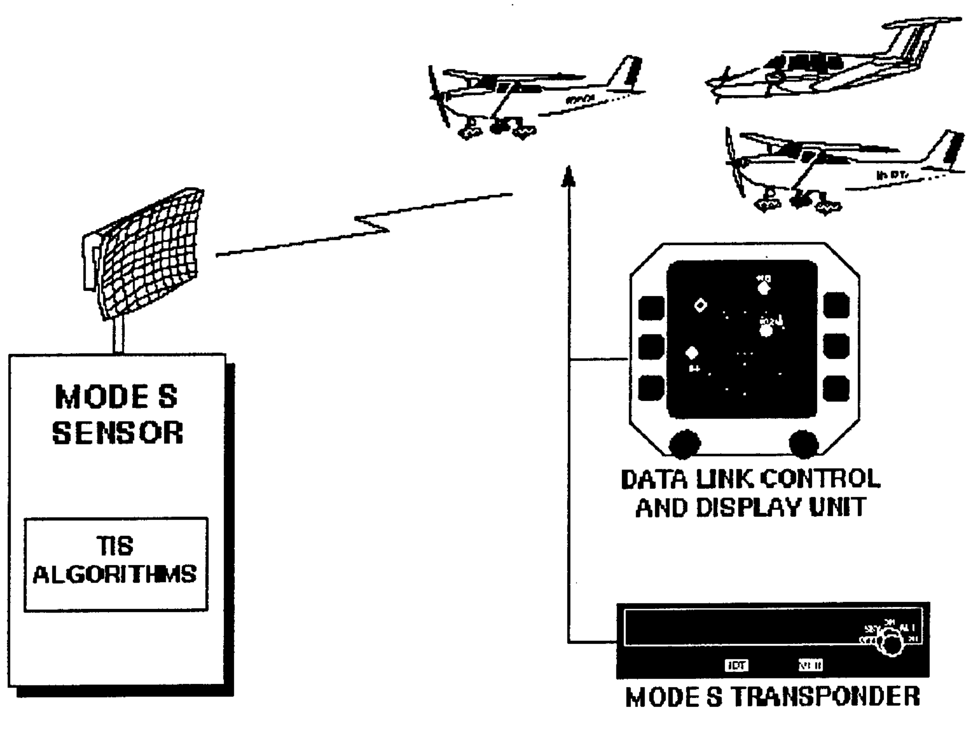


FIGURE 3.1- 1. FUNCTIONAL ELEMENTS OF TIS

While TIS can provide traffic information alerts to only those Mode S-equipped aircraft under surveillance track, TIS has knowledge of all Air Traffic Radar Beacon System (ATCRBS) aircraft in coverage (and, potentially, of nontransponder-equipped aircraft when a primary radar's coverage is integrated with the Mode S sensor). TIS generates alerts for any traffic aircraft in Mode S coverage that carry a transponder (ATCRBS or Mode S). By utilizing the surveillance database maintained by Mode S ground interrogators and the data link, TIS can provide airborne traffic alerting with modest airborne equipage. The TIS service is provided without any ground controller involvement.

3.1.1 Differences Between TIS and TCAS.

TIS provides traffic advisories similar to those of Traffic Alert and Collision Avoidance System-Version I (TCAS-I), but does not provide resolution advisories. The major functional difference between TIS and TCAS is the source of surveillance data. TCAS uses an airborne interrogator with a 1-second update rate, while TIS uses the terminal Mode S ground interrogator and its data link to provide about a 5-second update rate. The range accuracy of TIS and TCAS are similar. TCAS angular accuracy is limited to a few degrees of azimuth measured with respect to the aircraft, while TIS angular accuracy is that of Mode S (about 1 milliradian) measured with respect to the ground interrogator. These differences in surveillance accuracy, coordinate system, and update rate impacted the design of TIS. The algorithms and parameters of TIS were developed to offset the differences in surveillance performance in order to yield comparable alerting service to TCAS-I.

3.2 TEST SYSTEM CONFIGURATION.

All testing was conducted at the Technical Center short-range radar test facility located in building 269, on Mode S sensor #1. This Mode S sensor is integrated with a collocated Airport Surveillance Radar Model 9 (ASR-9).

3.2.1 Hardware Configuration.

The hardware configuration that was used is essentially the same as the operational systems located in the field, with exception of the Aircraft Reply and Interference Environmental Simulator (ARIES). The hardware testbed is shown in figure 3.2.1-1 below, and consisted of the following items:

a. Dual-channel Terminal Configured Mode S sensor, with single face antenna
b. Collocated ASR-9 Radar
c. Local Maintenance Terminal (LMT)
d. Remote Terminal (RT)
e. Real-Time Aircraft Display System (RTADS)
f. Radar Intelligence Tool (RIT)
g. Aircraft Reply and Interference Environmental Simulator (ARIES)
h. Two aircraft equipped with Mode S transponders and prototype ADLP/TIS displays
i. Rack-mount Mode S transponders and prototype ADLP/TIS displays located on top of nearby Aircraft Hanger.

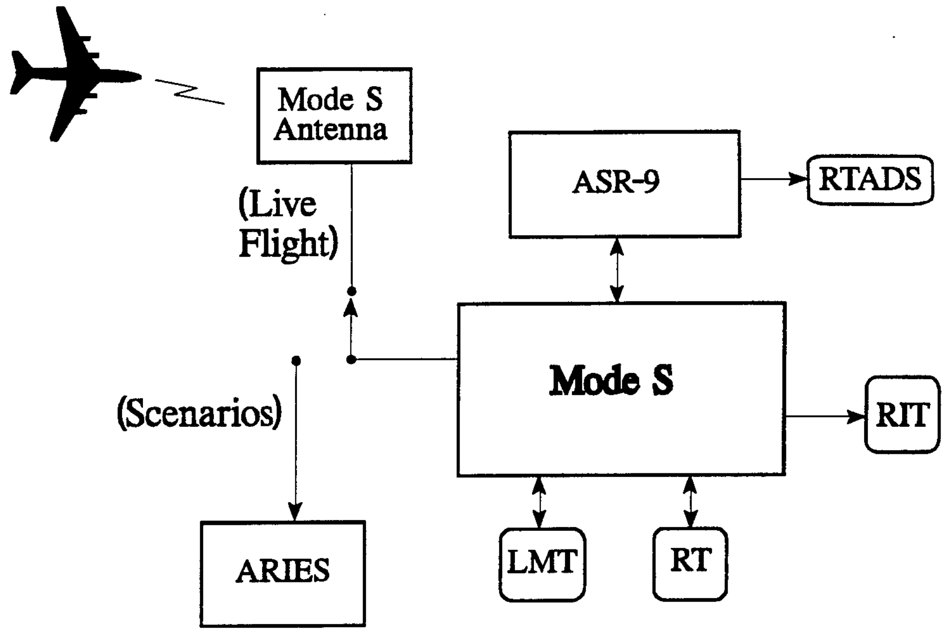


FIGURE 3.2.1- 1. MODE S HARDWARE ELEMENTS OF TIS TESTING

3.2.2 Software Configuration.

The TIS software configuration consisted of one System Configuration Management (SCM) controlled version, with two minor variants. The SCM version, SAR214.G, was used for all live flight-testing, and is the version that will ultimately get fielded. The two minor variations, SAR214G-TIS DEBUG and SAR214G-TISZCONE, each contained a one-line change to support the ARIES scenario testing and live-ground testing (aircraft hanger-mounted transponder setup), respectively.

SAR214G-TIS DEBUG was required because the test target simulator (ARIES) did not fully support the data link protocol used by TIS. A one-line change was made to use pilot-initiated downlinks instead of broadcast downlink messages to request TIS service. SAR214G-TISZCONE was required because of the sensors close proximity to the ground-based (aircraft hanger-mounted) transponder setup used during the regression testing. A one-line change was made to set the zenith cone buffer value to zero so the test transponder would be visible in the TIS coverage volume.

The Airborne Data Link Processor (ADLP) and TIS display software used during the TIS live flight tests was prototype code installed on laptop personal computers (PC). This software was not tested here but merely used a test tool to verify the ground-based TIS software. Additional testing will be required at a later date when production ADLPs are available.

3.3 INTERFACES.

The TIS software operates within the Terminal Mode S system and does not interface directly with any other NAS systems. It is totally self-contained within the Mode S sensor and does not affect surveillance data sent to Air Traffic (AT) facilities. The overall architecture of the TIS software is shown in figure 3.3-1. There are two TIS processing tasks: the tracker, and the alert generator. The tracker task receives inputs from the sensor surveillance functions and maintains a local TIS track file that is shared between the TIS tracker task and alert generation task. TIS tracks are updated at the time that surveillance inputs appear. Any TIS messages generated in the alert generation task are fed to the sensor data link functions for transmission to the client aircraft. Input from the sensor data link functions provides the source of TIS downlink request messages, which enable or disable TIS service to a particular client aircraft. TIS also attaches to the sensor software performance monitor and data extraction functions (not shown in figure 3.3-1).

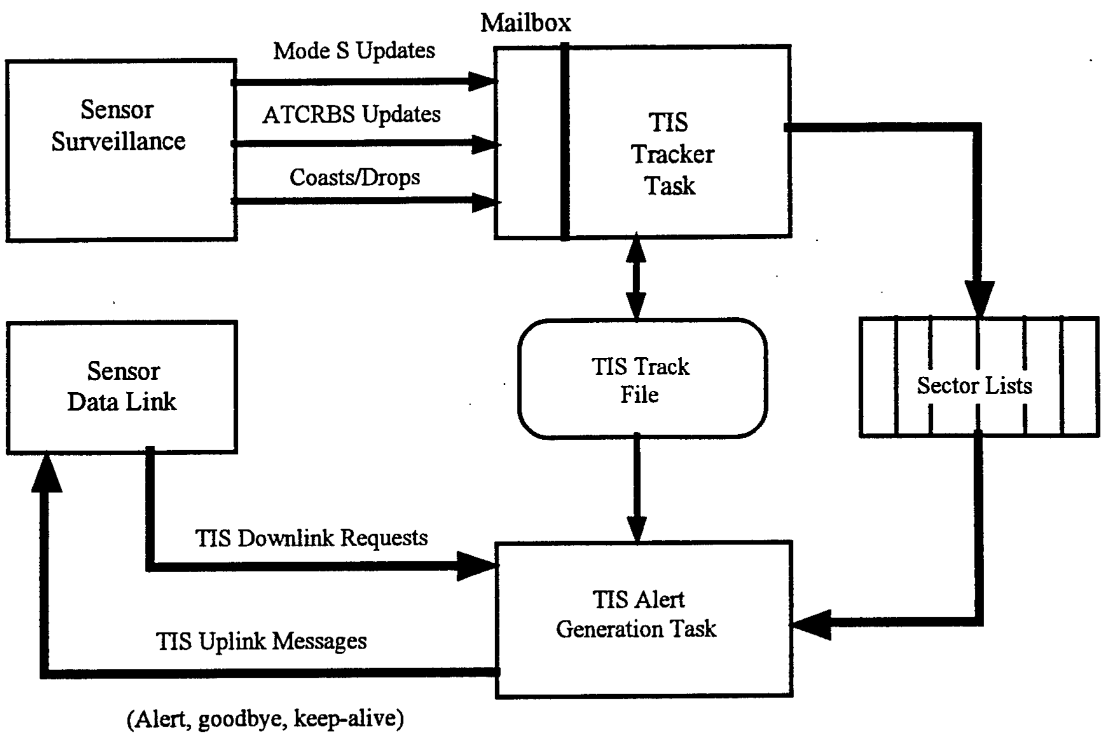


FIGURE 3.3- 1. ARCHITECTURE OF THE TIS SENSOR SOFTWARE

4. TEST AND EVALUATION DESCRIPTION.

The Test and Evaluation (T&E) Description provides details on how the TIS requirements were tested and verified. The TIS requirements were assigned to two major test categories; DT&E and OT&E. The following three test methods were used to verify the requirements within the DT&E and OT&E test categories:

a. software code inspection,
b. target scenario testing,
c. live flight testing.

The DT&E requirements were verified using software code inspection and analysis of test scenario data. The OT&E requirements were verified by analysis of test scenario data and live flight data. Each test method was conducted using a formal test procedure to ensure that all the requirements were tested.

4.1 SOFTWARE CODE INSPECTION.

This test method was used to verify requirements by visual examination against predefined inspection criteria. Code inspections consisted of an examination of code listings and no quantitative data recording was required other than completion of procedure check sheets.

4.1.1 Test Objective/Criteria.

The objective of this test method was to verify that the low-level TIS tracking algorithms and the alert processing routines function correctly, as defined in the TIS specification. The following TVRTM requirements were verified: 1, 12, 14-19, 21-31, 35, 45-66, 68, 70-76, 78, 80, 85-87, 91, 100, 104, 106, 119, 120, 122-125, 127, 128, 136, 137, 143-150, 153, 158, 160,164-167, 172-182, 193, 206, 207, 212-225, 229, 230, 238, 240, 247, 251, 256, 258, 266, 268, 276, 280, 284, 285, 288, 291, 293, 303-305, 307, 322-336, 338-342, 344.
NOTE: Detailed text for each of the requirements listed above can be found in the TVRTM located in appendix C.

4.1.2 Test Description.

The Code Inspection was conducted in a methodical and systematic manner using procedures that matched specific software code to a requirement that it satisfied. A source code listing of the SCM SAR214G Mode S image provided the baseline for the verification, which was done manually by visual inspection for each of the requirements.

The code inspection was conducted at the Technical Center in Atlantic City, NJ. This effort was started the week of July 14, 1997, and continued until completion on August 1, 1997. ACT-310 personnel performed the TIS software code inspection using the Mode S TIS DT&E and OT&E Code Inspection Test Procedure.

4.1.3 Data Collection and Analysis Method.

No formal data collection was required for the code inspection. Analysis consisted of visually comparing the selected software code sequences to the algorithms in the TIS specification.

4.1.4 Results/Discussion.

All the requirements verified in the code inspection were 100 percent correct.

4.1.5 Conclusions.

All TIS requirements associated with this test have been completely verified.

4.2 SCENARIO TESTING.

This test method was used to verify requirements by running test scenarios containing simulated targets that exercise the system in predefined, repeatable patterns, while collecting data for later analysis. Thirty test cases utilizing 37 different test scenarios were run to simulate various aircraft (client and intruder) flight paths, conflict conditions, and Terra/Non-Terra Mode S operational environments. Several generic and TIS specific analysis tools were then used to reduce the data. A complete listing of all the scenarios used for TIS testing is included in appendix A.

Within the 37 scenarios that were utilized, the following group is defined as the "basic 18":

TISCRCL4,	TISCRL8,	TISCRDS4,
TISCRDS8,	TISCRLL4,	TISCRLL8,
TISHOCL4,	TISHOL8,	TISHODS4,
TISHODS8,	TISHOLL4,	TISHOLL8,
TISOTCL4,	TISOTL8,	TISOTDS4,
TISOTDS8,	TISOTLL4,	TISOTLL8.

This set of 18 test scenarios, each of which consist of only 2 targets (client and intruder) in various types of encounters, were used to verify the TIS performance accuracy. The content and success criteria for these 18 scenarios is defined in the TIS Requirements Document (requirements 349 to 379). The resultant data extraction files have been analyzed to ensure requirement compliance. Any deficiencies were analyzed in detail to determine the cause of the failure. Failures due to bad surveillance data (input to TIS) were identified as such.

All scenario testing was conducted at the Technical Center, Mode S sensor #1 (building 269) using the SAR214G-TIS DEBUG software image and ARIES, between July 21 and August 1, 1997. All tests were conducted by ACT-310 personnel and support contractors.

One of the test conditions that is common to most all of the scenario and live flight tests were the Mode S data types extracted during each test run. They are listed below:

2 - Roll Call
5 - ATCRBS report
6 - Mode S report
9 - CD2 terminal
10 - ASR9 data
11 - SF ATCRBS synch
12 - SF Mode S sync
19 - Standard uplink
20 - ELM uplink
21 - Downlink request
22 - ATCRBS ID request
23 - Cancel request
24 - Reject delay notice
25 - Reject delay with IDs
26 - Uplink deliver notice
29 - ELM downlink
30 - ELM downlink position
31 - Capability message
32 - ATCRBS ID message
33 - Test request
34 – ATC fail recovery msg
35 – ATC capability req
36 - Sensor fail recov msg
37 - Control state msg
38 - Test response message
39 - Status message
40 - Track alert message
41 - WCP capability req
42 - State request
43 - Position request
44 - State message
45 - Position message
46 - Track drop message
49 - Sensor recov notice
78 - Pilot downlink
79 - Pilot downlink position
80 - Broadcast downlink
81 - Broadcast downlink position
82 - Ground init downlink
83 - Ground init downlink position
89 - TIS track file
90 - TIS report
91 - TIS alert
92 - TIS request

The following subsections contain the 30 test cases executed as part of the scenario testing.

4.2.1 TEST: Horizontal Tracking and Turn Prediction.

4.2.1.1 Test Objectives / Criteria .

The objective of this test was to verify the horizontal velocity values for a horizontal track state of SECOND, that the horizontal tracker uses alpha-beta smoothing algorithm (for track positions) and the turn detection algorithm (for track velocities) for horizontal track states that are MATURE. The following TVRTM requirements were verified: 138 - 141, 150 (dte).

4.2.1.2 Testing Description.

This test was conducted by running the TISXOVRB scenario on the ARIES while collecting a Mode S data extraction. The scenario includes one TIS client and a single intruder aircraft that approachs from 4 miles to the rear on an angle to within 1/4 mile of the client. The intruder then turns sharply and flys parallel to the client. The scenario was run to completion without any special conditions set.

4.2.1.3 Data Collection and Analysis.

The data extraction file was collected with data types shown in section 4.2.2 at the Mode S using file name MXOVRB1.723.

The TIS Tracker/Alert analysis tool was used to calculate tracker and alert data that was compared to the data recorded during the test. Also, the Radar Beacon Analysis Tool (RBAT) TIS Analysis tool was used on the test data so that the results could be looked at to ensure proper operation of the scenario.
The analysis output files generated were TXOVRB1.723 from TIS Analysis and QXOVRC1T.723 from the TIS Tracker tool.

4.2.1.4 Results / Discussion.

The analysis output files were reviewed to verify track states, check that the alpha-beta-smoothing algorithm was used, and check that the turn detection algorithm was used. The following TIS requirements were successfully verified as a result of data analysis on the TISXOVRB scenario: 138 – 141 and 150.

Note that during this scenario, although not a part of a specific requirement, an intruder crossover problem was shown to exist. As the intruder aircraft closely approached and then turned away from the client aircraft, before it crossed its path, was shown by the TIS algorithm to have crossed the client's track when it in fact had not.

The following reliability results were obtained from TIS Analysis for the data of this scenario. The Traffic Advisory is for intruders within 0.5 nautical mile (nmi) and 800 feet in altitude of the client and the Proximity Advisory is for intruders within 5 nmi and 1200 feet of the client. A description of the results listed is shown in appendix D.

Mode S		----Traffic Advisory---				---Proximity Advisory--		
Client	Id	Size	Rel	Size	FAlrm	Size	Rel	Size
1	a63796	13	100.0	13	0.0	39	97.4	38
TOTAL		13	100.0	13	0.0	39	97.4	38

	-----------------Reliability-----------------							
FAlrm	Size	Bear	Size	Range	Alt	ARate	Head	Stat
0.0	51	86.3	51	100.0	96.1	96.1	100.0	98.0
0.0	51	86.3	51	100.0	96.1	96.1	100.0	98.0

The bearing reliability is low because the TIS tracker lags during sharp turns by the aircraft.

4.2.1.5 Conclusions.

All TIS requirements associated with this test have been completely verified.

A TIS intruder tracking problem was observed when a fast maneuvering, intruding target flew very close to the client aircraft. This problem was initially observed during a flight test of the

OT&E for the Dulles demo in 1995. It is referred to as the "crossover problem." This test nario was created to duplicate that flight test maneuver. During the scenario, the intruder is splayed for five scans on the wrong side of the client aircraft on the TIS display screen. This rossover problem occurs because TIS sends the intruder's predicted position, one scan ahead, and the Mode S only gets updates once every 4 to5 seconds. When a fast approaching intruder gets within a quarter mile and abruptly turns (and doesn't cross the client's path) TIS predicts the intruder will appear on the other side of the client. It then takes several scans for the TIS tracker to correct this invalid prediction. This anomaly was only observed in this one test case, within 35 nmi of the Mode S sensor.

4.2.2 TEST: Traffic Alert Message and Ground Track.

4.2.2.1 Test Objectives / Criteria.

The objective of this test was to verify that the TIS Traffic Alert messages are composed of the 8-bit MSP header, the 6-bit message type field, and two Traffic Data Blocks. Also, that the first message in each group contains own-aircraft ground track angle; that the value of "own_track" is used in Message Type and Traffic Bearing determination. The following TVRTM requirements will then be verified: 259, 264, 267 (ote).

4.2.2.2 Testing Description.

This test was conducted by running the TISCRCL4 scenario on the ARIES while collecting a Mode S data extraction. The scenario includes one TIS client and one intruder on a Crossing course; Climbing in altitude, starting 45 miles from the sensor and the scenario was run to completion without any special conditions set.

4.2.2.3 Data Collection and Analysis.

The data extraction file was collected with data types shown in section 4.2.2 at the Mode S using file name MCRCL41.721.

The TIS Tracker/Alert analysis tool was used to calculate tracker and alert data which was compared to the data recorded during the test and the DR TIS List program was used to list the TIS alerts sent in roll call messages. Also, the TIS Analysis tool was used on the test data so that the results could be looked at to ensure proper operation of the scenario.
The analysis output files generated were TCRCL41.721 from TIS Analysis, QCRCL41T.721 from the TIS Tracker tool and LSTCRCL4.721 from the TIS list program.

4.2.2.4 Results / Discussion.

TIS Traffic Alert messages were checked for the correct message fields and the value of own track was checked along with its use. The following TIS requirements were verified as a result of data analysis on the TISCRCL4 scenario: 259, 264, 267.

4.2.2.5 Conclusions.

All TIS requirements associated with this test have been completely verified. There are no outstanding or new points of concern.

4.2.3 TEST: TIS Data Format and Vertical and Horizontal Update.

4.2.3.1 Test Objectives / Criteria.

The objective of this test was to verify that TIS receives data from the sensor in the correct units: range units (RU), azimuth units (AU), altitude (100 feet), and time units (TU), also angles shall be measured clockwise from North. When the TIS track has had at least two updates since its initiation vertical and horizontal updates shall be performed, including any changes to sort bin linkages based on these projections. The following TVRTM requirements will then be verified: 8-11 (ote) and 94-96 (dte).

4.2.3.2 Testing Description.

This test was conducted by running the TISCRCL8 scenario on the ARIES while collecting a Mode S data extraction. The scenario includes one TIS client and one intruder aircraft on a Crossing course, a Climbing flight, starting 8 miles from sensor and was run to completion without any special conditions set.

4.2.3.3 Data Collection and Analysis.

The data extraction file was collected with data types shown in section 4.2.2 at the Mode S using file name MCRCL81.721.

The TIS Tracker/Alert analysis tool was used to calculate tracker and alert data which was compared to the data recorded during the test and the DR TIS List program was used to list the TIS alerts sent in roll call messages. Also, the TIS Analysis tool was used on the test data so that the results could be looked at to ensure proper operation of the scenario.
The analysis output files generated were TCRCL81.721 from TIS Analysis, QCRCL81T.721 from the TIS Tracker tool and LSTCRCL8.721 from the TIS list program.

4.2.3.4 Results / Discussion.

The TIS messages and tracks were analyzed to ensure that the right data units of measurement were used. Also, the TIS output tracks were looked at to verify that horizontal and vertical updates were performed correctly. The following TIS requirements were verified as a result of data analysis on the TISCRCL8 scenario: 8-11 and 94-96.

4.2.3.5 Conclusions.

All TIS requirements associated with this test have been completely verified. There are no outstanding or new points of concern.

4.2.4 TEST: Message Type Value and Traffic Bearing.

4.2.4.1 Test Objectives / Criteria.

The objective of this test was to verify that the TIS keep-alive message type value and that the Traffic Bearing field contains the bearing angle from the own-aircraft to the alert aircraft in range increments 0 through 59 with respect to the sensor ground track. The following TVRTM requirements will then be verified: 272, 277-279, 296 (ote).

4.2.4.2 Testing Description.

This test was conducted by running the TISCRDS4 scenario on the ARIES while collecting a Mode S data extraction. The scenario includes one TIS client and one intruder on a Crossing course; Descending in altitude, starting 45 miles from the sensor and the scenario was run to completion without any special conditions set.

4.2.4.3 Data Collection and Analysis.

The data extraction file was collected with data types shown in section 4.2.2 at the Mode S using file name MCRDS41.721.

The TIS Tracker/Alert analysis tool was used to calculate tracker and alert data which was compared to the data recorded during the test and the DR TIS List program was used to list the TIS alerts sent in roll call messages. Also, the TIS Analysis tool was used on the test data so that the results could be looked at to ensure proper operation of the scenario.
The analysis output files generated were TCRDS41.721 from TIS Analysis, QCRDS41T.721 from the TIS Tracker tool and LSTCRDS4.721 from the TIS list program.

4.2.4.4 Results / Discussion.

The TIS message Traffic Bearing field was checked for the correct values and TIS keep-alive messages were checked to ensure that the right values were used. The following TIS requirements were verified as a result of data analysis on the TISCRDS4 scenario: 272, 277-279, 296.

4.2.4.5 Conclusions.

All TIS requirements associated with this test have been completely verified. There are no outstanding or new points of concern.

4.2.5 TEST: Slow Search, Alert Determination, and Odd Alert Count.

4.2.5.1 Test Objectives / Criteria.

The objective of this test was to verify that a slow search is equivalent to the fast search except that the range of bins to search is determined by the speed of the input TIS track; that the alert determination process is called for all potential alert tracks and computes the difference in the x- and y-direction position and velocity; and the altitude values (difference and absolute) are calculated. Also, during this test, when an odd number of alerts occur, the following will be verified; that the second Traffic Data Block in the last alert contains no traffic data; that the traffic bearing field in last message is set to 63 and remaining 15 bits are unused; and the 3-bit Traffic Heading field contains the ground track angle of the alert aircraft. The following TVRTM requirements will then be verified: 202-204, 208, 209 (dte) and 254, 255, 265, 292 (ote).

4.2.5.2 Testing Description.

This test was conducted by running the TISCRDS8 scenario on the ARIES while collecting a Mode S data extraction. The scenario includes one TIS client and one intruder on a Crossing course; Descending in altitude, starting 8 miles from the sensor and the scenario was run to completion without any special conditions set.

4.2.5.3 Data Collection and Analysis.

The data extraction file was collected with data types shown in section 4.2.2 at the Mode S using file name MCRDS81.721.

The TIS Tracker/Alert analysis tool was used to calculate tracker and alert data which was compared to the data recorded during the test and the DR TIS List program was used to list the TIS alerts sent in roll call messages. Also, the TIS Analysis tool was used on the test data so that the results could be looked at to ensure proper operation of the scenario.
The analysis output files generated were TCRDS81.721 from TIS Analysis, QCRDS81T.721 from the TIS Tracker tool, QCRDS81A.721 from the TIS Alert tool, and LSTCRDS8.721 from the TIS list program.

4.2.5.4 Results / Discussion.

The speed of the TIS track was used to check whether a slow or fast search of potential alerts was done. Then alert determination processing was checked to make sure that all alerts were computed correctly. Also, TIS traffic alert messages were checked when there was an odd number of alerts to make sure that all corresponding data fields contained the right data. Finally, the Traffic Heading field of the alert message was checked for correct data.
The following TIS requirements were verified as a result of data analysis on the TISCRDS8 scenario: 202-204, 208, 209, 254, 255, 265, and 292.

4.2.5.5 Conclusions.

All TIS requirements associated with this test have been completely verified. There are no outstanding or new points of concern.

4.2.6 TEST: Sector List Processing and Coarse Screening.

4.2.6.1 Test Objectives / Criteria.

The objective of this test was to verify that the TIS tracks requesting TIS service are linked to the sector list appropriate for their azimuth sector; that the TIS tracks linked to a sector list are processed at a later time; that the TIS Alert Generation task executes periodically to process entries from the sector lists generating uplink messages, and that a coarse screening process searches the track file for tracks close enough in the horizontal direction to generate alerts. The following TVRTM requirements will then be verified: 168, 169, 171, 192 (ote).

4.2.6.2 Testing Description.

This test was conducted by running the TISCRLL4 scenario on the ARIES while collecting a Mode S data extraction. The scenario includes one TIS client and one intruder aircraft on a Crossing course, at Level flight, starting 45 miles from sensor and the scenario was run to completion without any special conditions set.

4.2.6.3 Data Collection and Analysis.

The data extraction file was collected with data types shown in section 4.2.2 at the Mode S using file name MCRLL41.721.

The TIS Tracker/Alert analysis tool was used to calculate tracker and alert data which was compared to the data recorded during the test and the DR TIS List program was used to list the TIS alerts sent in roll call messages. Also, the TIS Analysis tool was used on the test data so that the results could be looked at to ensure proper operation of the scenario.
The analysis output files generated were TCRLL41.721 from TIS Analysis, QCRLL41T.721 from the TIS Tracker tool, and LSTCRLL4.721 from the TIS list program.

4.2.6.4 Results / Discussion.

The TIS track files were checked for correct processing of TIS requests and that the sector lists are used correctly when processing TIS tracks and generating alerts from them. Also, all alerts were checked to ensure that the horizontal separation from the client was right. The following TIS requirements were verified as a result of data analysis on the TISCRLL4 scenario: 168, 169, 171, 192.

4.2.6.5 Conclusions.

All TIS requirements associated with this test have been completely verified. There are no outstanding or new points of concern.

4.2.7 TEST: Current Position Comparison and Position Updates.

4.2.7.1 Test Objective / Criteria.

The objective of this test was to verify that if the Mode S track is receiving TIS, the input handler compares the current position with the TIS coverage map, and that the updated TIS tracks are moved to their appropriate sector lists. Also, for ATCRBS messages that are not track drops, that the input handler computes update time periods for the horizontal and vertical trackers; and if all time periods are positive, the input handler computes a vertical position "ZR" from the message altitude. The following TVRTM requirements will then be verified: 112, 118 (ote) and 90, 92 (dte).

4.2.7.2 Testing Description.

This test was conducted by running the TISCRLL8 scenario on the ARIES while collecting a Mode S data extraction. The scenario includes one TIS client and one intruder aircraft on a Crossing course, at Level flight, starting 8 miles from sensor and was run to completion without any special conditions set.

4.2.7.3 Data Collection and Analysis.

The data extraction file was collected with data types shown in section 4.2.2 at the Mode S using file name MCRLL81.721.

The TIS Tracker/Alert analysis tool was used to calculate tracker and alert data which was compared to the data recorded during the test and the DR TIS List program was used to list the TIS alerts sent in roll call messages. Also, the TIS Analysis tool was used on the test data so that the results could be looked at to ensure proper operation of the scenario.
The analysis output files generated were TCRLL81.721 from TIS Analysis, QCRLL81T.721 from the TIS Tracker tool, and LSTCRLL8.721 from the TIS list program.

4.2.7.4 Results / Discussion.

Mode S track updates for TIS tracks were checked for the correct placement of the tracks. Update time periods computed from input ATCRBS messages were compared with the output time periods. Also, the computation of vertical position (ZR) was checked. The following TIS requirements were verified as a result of data analysis on the TISCRLL8 scenario: 90, 92, 112, and 118.

4.2.7.5 Conclusions.

All TIS requirements associated with this test have been completely verified. There are no outstanding or new points of concern.

4.2.8 TEST: Second Traffic Information Block.

4.2.8.1 Test Objectives / Criteria.

The objective of this test was to verify that in a TIS message, with only one traffic aircraft, the Traffic Bearing value is 63 in the unused Traffic Information Block and that the remainder of the bits are set to zero indicating no valid information. Also, that the Traffic Range and the Relative Altitude fields contain the correct data as it relates to own-aircraft. The following TVRTM requirements will then be verified: 281-283, 287 (ote).

4.2.8.2 Testing Description.

This test was conducted by running the TISHOCL4 scenario on the ARIES while collecting a Mode S data extraction. The scenario includes one TIS client and one intruder on a Head-On course; Climbing in altitude, starting 45 miles from the sensor and the scenario was run to completion without any special conditions set.

4.2.8.3 Data Collection and Analysis.

The data extraction file was collected with data types shown in section 4.2.2 at the Mode S using file name MHOCL41.721.

The TIS Tracker/Alert analysis tool was used to calculate tracker and alert data which was compared to the data recorded during the test, and the DR TIS List program was used to list the TIS alerts sent in roll call messages. Also, the TIS Analysis tool was used on the test data so that the results could be looked at to ensure proper operation of the scenario.
The analysis output files generated were THOCL41.721 from TIS Analysis, QHOCL41T.721 from the TIS Tracker tool and LSTHOCL4.721 from the TIS list program.

4.2.8.4 Results / Discussion.

The TIS messages were checked for correct information when there is only one traffic aircraft. Also, the contents of the Traffic Range field and the Relative Altitude field in the Traffic Information Block were checked for the correct contents. The following TIS requirements were verified as a result of data analysis on the TISHOCL4 scenario: 281-283, 287.

A self-alert was found during the analysis of the data for this scenario. It showed that a code swap had occurred causing the altitude of the client's ATCRBS track to drop 600 feet. RBAT Surveillance Print was used and the output file was SPHOCL41.721.

4.2.8.5 Conclusions.

All TIS requirements associated with this test have been completely verified.

An explanation for the cause and affect of the self-alert found in this scenario can be found in section 4.2.29.5. This problem is characterized as "due to surveillance deficiencies" and is not attributed to the TIS software.

4.2.9 TEST: Altitude Processing, Track and Alert Formatting, and TERRA Processing.

4.2.9.1 Test Objectives / Criteria.

The objective of this test was to verify the correct operation of the altitude tracker processing; that each TIS track on a sector list is formatted; and that the data is passed on to sensor data link functions. Also, that additional processing is performed under Terra to prevent "self-alerts" during the alert determination process and that the alerts are shown in the extracted data. The following TVRTM requirements will then be verified: 164 (dte) and 190, 191, 211, 248, 252, 253 (ote).

4.2.9.2 Testing Description.

This test was conducted by running the TISHOCL8 scenario on the ARIES while collecting a Mode S data extraction. The scenario includes one TIS client and one intruder aircraft on a Head-On course, Climbing during the flight, starting 8 miles from sensor.

a. The TISHOCL8 scenario was run once in Terra mode with default SAP settings and then the NONHOCL8 scenario was run for Non-Terra mode.

4.2.9.3 Data Collection and Analysis.

The data extraction files were collected with data types shown in section 4.2.2 at the Mode S using file names MHOCL81.721 and MNHOCL81.724.

The TIS Tracker/Alert analysis tool was used to calculate tracker and alert data which was compared to the data recorded during the test, and the DR TIS List program was used to list the TIS alerts sent in roll call messages. Also, the TIS Analysis tool was used on the test data so that the results could be looked at to ensure proper operation of the scenario.
The analysis output files generated were THOCL81.721 from TIS Analysis, QHOCL81T.721 from the TIS Tracker tool, and LSTHOCL8.721 from the TIS list program. The Non-Terra output files were TNHOCL81.724 from TIS Analysis.

4.2.9.4 Results / Discussion.

With Terra mode in effect, checks for self-alerts were made. Data extraction was verified and altitude tracker processing was checked. Also, all TIS uplink messages, including traffic alert messages, were checked for completeness and correct formatting. The following TIS requirements were verified as a result of data analysis on the TISHOCL8 and NONHOCL8 scenarios: 164, 190, 191, 211, 248, 252, and 253.

4.2.9.5 Conclusions.

All TIS requirements associated with this test have been completely verified. There are no outstanding or new points of concern.

4.2.10 TEST: Data Extraction, Horizontal Tracker, and Transition State.

4.2.10.1 Test Objectives / Criteria.

The objective of this test was to verify that the data extraction of all TIS categories works correctly; that ground range and input report azimuth are used to compute the reports x-y coordinates; that for ATCRBS track updates the TIS horizontal tracker updates the horizontal components of the TIS track and any changes in the TIS track sort bin linkages are performed; that when the "trans_flag" is TRUE then the Transition State update is performed, otherwise, the No Transition State update is performed; that the altitude tracking function works correctly; and that the initial altitude processing works correctly. The following TVRTM requirements will then be verified: 105, 347, 348 (ote) and 101-103, 159, 161, 162 (dte).

4.2.10.2 Testing Description.

This test was conducted by running the TISHODS5 scenario on the ARIES while collecting a Mode S data extraction. The scenario includes one TIS client and one intruder aircraft on a Head-On course, at Descending flight, starting 45 miles from sensor and was run to completion without any special conditions set.

4.2.10.3 Data Collection and Analysis.

The data extraction file was collected with data types shown in section 4.2.2 at the Mode S using file name MHODS51.721.

The TIS Tracker/Alert analysis tool was used to calculate tracker and alert data which was compared to the data recorded during the test and the DR TIS List program was used to list the TIS alerts sent in roll call messages. Also, the TIS Analysis tool was used on the test data so that the results could be looked at to ensure proper operation of the scenario.
The analysis output files generated were THODS51.721 from TIS Analysis, QHODS51T.721 from the TIS Tracker tool, QHODS51A.721 from the TIS Alert tool, and LSTHODS5.721 from the TIS list program.

4.2.10.4 Results / Discussion.

All data extraction results were checked for correctness. The TIS reported x-y coordinates were verified. The TIS horizontal tracker updates were checked. Transition State outputs were verified and TIS altitude state outputs were checked.
The following TIS requirements were verified as a result of data analysis on the TISHODS5 scenario: 101-103, 105, 159, 161, 162, 347, and 348.

4.2.10.5 Conclusions.

All TIS requirements associated with this test have been completely verified. There are no outstanding or new points of concern.

4.2.11 TEST: Mature Track Request and Track Entries.

4.2.11.1 Test Objectives / Criteria.

The objective of this test was to verify that each mature track requesting service received either traffic data or keep-alive uplink messages at least every 60 seconds and that the TIS alerts/message category include the track entries for the client and intruder tracks. The following TVRTM requirements would then be verified: 337, 346 (ote).

4.2.11.2 Testing Description.

This test was conducted by running the TISHODS8 scenario on the ARIES while collecting a Mode S data extraction. The scenario includes one TIS client and one intruder on a Head-On course; Descending in altitude, starting 8 miles from the sensor and the scenario was run to completion without any special conditions set.

4.2.11.3 Data Collection and Analysis.

The data extraction file was collected with data types shown in section 4.2.2 at the Mode S using file name MHODS81.721.

The TIS Tracker/Alert analysis tool was used to calculate tracker and alert data which was compared to the data recorded during the test and the DR TIS List program was used to list the TIS alerts sent in roll call messages. Also, the TIS Analysis tool was used on the test data so that the results could be looked at to ensure proper operation of the scenario.
The analysis output files generated were THODS81.721 from TIS Analysis, QHODS81T.721 from the TIS Tracker tool, and LSTHODS8.721 from the TIS list program.

4.2.11.4 Results / Discussion.

The clients aircraft data was checked to make sure it got either a keep-alive message or traffic data every 60 seconds. Also, the TIS track data was checked to make sure both client and intruder data was present. The following TIS requirements were verified as a result of data analysis on the TISHODS8 scenario: 337 and 346.

The following reliability results were obtained from TIS Analysis for the data of this scenario. A description of the results listed is shown in appendix D.

Mode S		----Traffic Advisory---				---Proximity Advisory		
Client	Id	Size	Rel	Size	FAlrm	Size	Rel	Size
1	faa001	4	100.0	4	0.0	42	95.2	40
TOTAL		4	100.0	4	0.0	42	95.2	40

	--------	--------	--------	Reliability	--------	--------	--------	--------
FAlrm	Size	Bear	Size	Range	Alt	ARate	Head	Stat
0.0	44	84.1	44	100.0	95.5	100.0	100.0	100.0
0.0	44	84.1	44	100.0	95.5	100.0	100.0	100.0

This scenario has extra intruders (0003 & 0004) that are short-time targets. At the end of their time periods they both coast without bearing and altitude data because of the way the ARIES scenario is written. This is the reason why the bearing and altitude results are less than 100 percent.

4.2.11.5 Conclusions.

All TIS requirements associated with this test have been completely verified. There are no outstanding or new points of concern except for the low bearing reliability as explained previously. This problem is characterized as "due to surveillance deficiencies" and is not attributed to the TIS software.

4.2.12 TEST: Sensor Surveillance Processing and Coordinate Conversion.

4.2.12.1 Test Objective / Criteria.

The objective of this test was to verify that the TIS tracker task receives inputs from the sensor surveillance processing functions and maintains a local TIS track file; that TIS tracks receiving TIS service are linked to their appropriate sector lists; and that position, altitude, and time are taken from the surveillance track file entry after it is updated by the input report. Also, when the input ATCRBS message is a track update, the handler converts the report coordinates from range-azimuth to x-y with the first step being to calculate the report ground range using the report vertical position ZR. The following TVRTM requirements will then be verified: 77, 79, 84 (ote) and 98, 99 (dte).

4.2.12.2 Testing Description.

This test was conducted by running the TISHOLL4 scenario on the ARIES while collecting a Mode S data extraction. The scenario includes one TIS client and one intruder aircraft on a Head-On course, at Level flight, starting 45 miles from sensor and was run to completion without any special conditions set.

4.2.12.3 Data Collection and Analysis.

The data extraction file was collected with data types shown in section 4.2.2 at the Mode S using file name MHOLL41.721.

The TIS Tracker/Alert analysis tool was used to calculate tracker and alert data which was compared to the data recorded during the test, and the DR TIS List program was used to list the

TIS alerts sent in roll call messages. Also, the TIS Analysis tool was used on the test data so that the results could be looked at to ensure proper operation of the scenario.
The analysis output files generated were THOLL41.721 from TIS Analysis and QHOLL41T.721 from the TIS Tracker tool.

4.2.12.4 Results / Discussion.

All TIS track outputs were listed and checked for correctness. Also, x – y coordinates and vertical positions (ZR) were verified for ATCRBS type messages. The following TIS requirements were verified as a result of data analysis on the TISHOLL4 scenario: 77, 79, 84, 98, and 99.

Analysis of the data for this scenario found that a self-alert occurred. The self-alert was caused by a code swap, which in turn caused an azimuth difference in the tracking of the clients ATCRBS ID. Also, after the code swap, for one scan there was no ATCRBS report except one for an unknown ID 0003. Finally, when recovering from the code swap the altitudes for ID's 0001 and 0002 were swapped for one scan. RBAT Surveillance Print was used for this analysis and the output file was SPHOLL41.721.

The following reliability results were obtained from TIS Analysis for the data of the scenario. A description of the results listed is shown in appendix D.

Mode S		----Traffic Advisory---				---Proximity Advisory		
Client	Id	Size	Rel	Size	FAlrm	Size	Rel	Size
1	faa001	9	100.0	11	18.2	20	100.0	20
TOTAL		9	100.0	11	18.2	20	100.0	20

	-----------------Reliability-----------------							
FAlrm	Size	Bear	Size	Range	Alt	ARate	Head	Stat
0.0	26	100.0	29	96.6	86.2	93.1	100.0	100.0
0.0	26	100.0	29	96.6	86.2	93.1	100.0	100.0

Note that the altitude reliability is below the 90 percent success rate. This is directly attributed to the self-alert and code swap found in this scenario.

4.2.12.5 Conclusions.

All TIS requirements associated with this test have been completely verified.

An explanation for the cause and affect of the self-alert found in this scenario can be found in section 4.2.29.5. This problem is characterized as "due to surveillance deficiencies" and is not attributed to the TIS software.

4.2.13 TEST: Tracker and Alert Generation and TAU.

4.2.13.1 Test Objectives / Criteria.

The objective of this test was to verify the correct operation of the tracker and alert generation tasks, the processing of a TIS track update during level flight, and the determination that threat and proximity alerts can be calculated correctly using the "tau" value. Also, that the tau values are passed to the data extraction function. The following TVRTM requirements will then be verified: 2-6, 241 (ote) and 163, 226-228 (dte).

4.2.13.2 Testing Description.

This test was conducted by running the TISHOLL8 scenario on the ARIES while collecting a Mode S data extraction. The scenario includes one TIS client and one intruder aircraft on a Head-On course, at Level flight, starting 8 miles from sensor and was run to completion without any special conditions set.

4.2.13.3 Data Collection and Analysis.

The data extraction file was collected with data types shown in section 4.2.2 at the Mode S using file name MHOLL81.721.

The TIS Tracker/Alert analysis tool was used to calculate tracker and alert data which was compared to the data recorded during the test and the DR TIS List program was used to list the TIS alerts sent in roll call messages. Also, the TIS Analysis tool was used on the test data so that the results could be looked at to ensure proper operation of the scenario.
The analysis output files generated were THOLL81.721 from TIS Analysis, QHOLL81T.721 from the TIS Tracker tool, QHOLL81A from the TIS Alert tool, and LSTHOLL8.721 from the TIS list program.

4.2.13.4 Results / Discussion.

TIS tracks and alerts were listed and verified for correct updates. This proved the correct operation of the TIS tracker and alert generation tasks. In this scenario, with no altitude transition, TIS track updates have a value difference of no more than a foot from the analysis tool. Also, all TAU values were checked for correctness with vertical and horizontal TAU's having a difference of less than 8 seconds from that calculated by the analysis tool. The following TIS requirements were verified as a result of data analysis on the TISHOLL8 scenario: 2-6, 163, 226-228, and 241.

4.2.13.5 Conclusions.

All TIS requirements associated with this test have been completely verified. There are no outstanding or new points of concern.

4.2.14 TEST: Traffic Information Block and Keep-Alive Message.

4.2.14.1 Test Objective / Criteria.

The objective of this test was to verify that the Altitude Rate and the Traffic Status fields contain the correct data as it relates to the alert aircraft. Also, that a "keep-alive" message is generated to the selected aircraft that had traffic on the previous scan and the current update does not, and that the remaining 42 bits of the "keep-alive" message are set to zero. The following TVRTM requirements will then be verified: 289, 294, 295, 297 (ote).

4.2.14.2 Testing Description.

This test was conducted by running the TISOTCL4 scenario on the ARIES while collecting a Mode S data extraction. The scenario includes one TIS client and one intruder on an Overtaking course, Climbing in altitude, starting 45 miles from the sensor and the scenario was run to completion without any special conditions set.

4.2.14.3 Data Collection and Analysis.

The data extraction file was collected with data types shown in section 4.2.2 at the Mode S using file name MOTCL41.722.

The TIS Tracker/Alert analysis tool was used to calculate tracker and alert data which was compared to the data recorded during the test and the DR TIS List program was used to list the TIS alerts sent in roll call messages. Also, the TIS Analysis tool was used on the test data so that the results could be looked at to ensure proper operation of the scenario.
The analysis output files generated were TOTCL41.722 from TIS Analysis, QOTCL41T.722 from the TIS Tracker tool, and LSTOTCL4.722 from the TIS list program.

4.2.14.4 Results / Discussion.

The Altitude Rate field for TIS alert was checked for a correct climbing indication. The Traffic Status field was checked for proximity and traffic indications. The TIS alert messages were checked to make sure that a goodbye message was generated when a previous scan had traffic for the client aircraft and the current scan does not. Lastly it was checked that the last 42 bits of a TIS keep-alive message are cleared to zero. The following TIS requirements were verified as a result of data analysis on the TISOTCL4 scenario: 289, 294, 295, and 297.

4.2.14.5 Conclusions.

All TIS requirements associated with this test have been completely verified. There are no outstanding or new points of concern.

4.2.15 TEST: Horizontal Tracker Update and Altitude Tracker.

4.2.15.1 Test Objective / Criteria.

The objective of this test was to verify that the horizontal tracker update period is at least 2 seconds; that the horizontal tracker updates the TIS track's sort bin linkage for tracks whose state is THIRD or MATURE; that the driver for the TIS altitude tracker computes the altitude projected to the current time; that the TIS altitude tracker driver sets variables for the various altitude tracker states; and when the TIS tracks altitude state is INITIALIZE processing for the initialization state is performed. The following TVRTM requirements will then be verified: 126, 151, 154, 156, 157 (dte).

4.2.15.2 Testing Description.

This test was conducted by running the TISOTCL8 scenario on the ARIES while collecting a Mode S data extraction. The scenario includes one TIS client and one intruder aircraft on an Overtaking course, Climbing flight, starting 8 miles from sensor and was run to completion without any special conditions set.

4.2.15.3 Data Collection and Analysis.

The data extraction file was collected with data types shown in section 4.2.2 at the Mode S using file name MOTCL81.722.

The TIS Tracker/Alert analysis tool was used to calculate tracker and alert data which was compared to the data recorded during the test and the DR TIS List program was used to list the TIS alerts sent in roll call messages. Also, the TIS Analysis tool was used on the test data so that the results could be looked at to ensure proper operation of the scenario.
The analysis output files generated were TOTCL81.722 from TIS Analysis, QOTCL81T.722 from the TIS Tracker tool, and LSTOTCL8.722 from the TIS list program.

4.2.15.4 Results / Discussion.

The TIS tracker outputs were checked to make sure that the horizontal tracker function was working correctly. The same outputs were then checked to verify the correct operation of the TIS altitude tracker.
The following TIS requirements were verified as a result of data analysis on the TISOTCL8 scenario: 126, 151, 154, 156, and 157.

4.2.15.5 Conclusions.

All TIS requirements associated with this test have been completely verified. There are no outstanding or new points of concern.

4.2.16 TEST: Altitude Rate and Message Format.

4.2.16.1 Test Objective / Criteria.

The objective of this test is to verify that the Altitude Rate field contains the correct data as it relates to the alert aircraft and is processed by the sensor software data link function. Also, that the uplink messages are in "Comm-A" 56-bit format and that no uplink message has a number of zero. The following TVRTM requirements will then be verified: 289, 301, 302, 306 (ote).

4.2.16.2 Testing Description.

This test was conducted by running the TISOTDS4 scenario on the ARIES while collecting a Mode S data extraction. The scenario includes one TIS client and one intruder on an Overtaking course; Descending in altitude, starting 45 miles from the sensor and the scenario was run to completion without any special conditions set. Data type 48 (Active Message List) is added to extraction types for requirement 306.

4.2.16.3 Data Collection and Analysis.

The data extraction file was collected with data types shown in section 4.2.2 at the Mode S using file name MOTDS41.723.

The TIS Tracker/Alert analysis tool was used to calculate tracker and alert data which was compared to the data recorded during the test and the DR TIS List program was used to list the TIS alerts sent in roll call messages. The RBAT Miscellaneous Print option was used to display message numbers. Also, the TIS Analysis tool was used on the test data so that the results could be looked at to ensure proper operation of the scenario.
RBAT Miscellaneous Print was on the output file selecting data type 48 to verify message numbers.
The analysis output files generated were TOTDS41.723 from TIS Analysis, QOTDS41T.723 from the TIS Tracker tool, LSTOTDS4.723 from the TIS list program, and MPOTDS41.723 from RBAT Miscellaneous Print.

4.2.16.4 Results / Discussion.

The format of all TIS uplink messages was checked. This included the 2-bit altitude rate field. Also, using RBAT Miscellaneous Print option the message numbers were checked, including the non-use of number zero. The following TIS requirements were verified as a result of data analysis on the TISOTDS4 scenario: 289, 301, 302, and 306.

Analysis of the data for this scenario showed that a self-alert had occurred. The self-alert was caused because of a code swap and a coasting condition which made the clients ATCRBS altitude drop 1100 feet. RBAT Surveillance Print was used for this with an output file of SPOTDS41.723.

4.2.16.5 Conclusions.

All TIS requirements associated with this test have been completely verified.

An explanation for the cause and affect of the self-alert found in this scenario can be found in section 4.2.29.5. This problem is characterized as "due to surveillance deficiencies" and is not attributed to the TIS software.

4.2.17 TEST: Uplink Message Format.

4.2.17.1 Test Objective / Criteria.

The objective of this test is to verify the format of the uplink messages (Mode S Comm-A): size, Mode S Specific Protocol (MSP) header, message type, and Traffic Data Blocks. The following TVRTM requirements will then be verified: 242-246 (ote).

4.2.17.2 Testing Description.

This test was conducted by running the TISOTDS8 scenario on the ARIES while collecting a Mode S data extraction. The scenario includes one TIS client and one intruder on an Overtaking course; Descending in altitude, starting 8 miles from the sensor and the scenario was run to completion without any special conditions set.

4.2.17.3 Data Collection and Analysis.

The data extraction file was collected with data types shown in section 4.2.2 at the Mode S using file name MOTDS81.722.

The TIS Tracker/Alert analysis tool was used to calculate tracker and alert data which was compared to the data recorded during the test and the DR TIS List program was used to list the TIS alerts sent in roll call messages. Also, the TIS Analysis tool was used on the test data so that the results could be looked at to ensure proper operation of the scenario.
The analysis output files generated were TOTDS81.722 from TIS Analysis, QOTDS81T.722 from the TIS Tracker tool, and LSTOTDS8.722 from the TIS list program.

4.2.17.4 Results / Discussion.

All TIS uplink messages were listed and the contents were checked for correctness. The Mode S Specific Protocol header, the message type field, and the Traffic Data Blocks were all checked for the right information.
The following TIS requirements were verified as a result of data analysis on the TISOTDS8 scenario: 242-246.

Analysis of the data for this scenario showed that a false alert occurred when the client and intruder were not near each other. Further analysis revealed that both the client (ATCRBS ID 0001) and the intruder (ATCRBS ID 0002) had code swaps at this time causing altitude and range discrepancies. These discrepancies showed target reports that were closer to each other than actuality, thereby causing the alert. This code swapping can be traced to the "Terra fix" problem. RBAT Surveillance Print was used for this analysis with an output file of SPOTDS81.722. See section 4.2.29.5 for further details.

4.2.17.5 Conclusions.

All TIS requirements associated with this test have been completely verified. There are no outstanding or new points of concern except for the false alert problem described previously. This problem is characterized as "due to surveillance deficiencies" and is not attributed to the TIS software.

4.2.18 TEST: Generation Timing, Coarse Screening, Altitude Rate, and Generation of a Traffic Block.

4.2.18.1 Test Objective / Criteria.

The objective of this test is to verify that for each TIS track on a sector list the alert generation timing test is performed and the coarse screening procedure is invoked to find potential traffic tracks which are checked for alerts; and that the 2-bit Altitude Rate field indicates a 3 (level). Also, to verify the correct generation of a Traffic Data Block to project the position of the traffic and own-aircraft. The following TVRTM requirements will then be verified: 183-185, 289 (ote) and 275 (dte).

4.2.18.2 Testing Description.

This test was conducted by running the TISOTLL4 scenario on the ARIES while collecting a Mode S data extraction. The scenario includes one TIS client and one intruder aircraft on an Overtaking course, at Level flight, starting 45 miles from sensor and was run to completion without any special conditions set.

4.2.18.3 Data Collection and Analysis.

The data extraction file was collected with data types shown in section 4.2.2 at the Mode S using file name MOTLL41.722.

The TIS Tracker/Alert analysis tool was used to calculate tracker and alert data which was compared to the data recorded during the test, and the DR TIS List program was used to list the TIS alerts sent in roll call messages. Also, the TIS Analysis tool was used on the test data so that the results could be looked at to ensure proper operation of the scenario.
The analysis output files generated were TOTLL41.722 from TIS Analysis, QOTLL41T.722 from the TIS Tracker tool, QOTLL41A.722 from the TIS Alert tool, and LSTOTLL4.722 from the TIS list program.

4.2.18.4 Results / Discussion.

All TIS tracks were looked at to make sure that alert generation was performed correctly and at the right time. The Altitude Rate field of the TIS uplink message was checked for the correct code. The TIS Traffic Data was checked to make sure that it was projected correctly from the radar scan time. The following TIS requirements were verified as a result of data analysis on the TISOTLL4 scenario: 183-185, 275, and 289.

Analysis of the data for this scenario showed that a self-alert had occurred. A coasting condition had caused the clients ATCRBS ID to increase its altitude by 500 feet. RBAT Surveillance Print was used for this analysis with an output file of SPOTLL41.722.

4.2.18.5 Conclusions.

All TIS requirements associated with this test have been completely verified.

An explanation for the cause and affect of the self-alert found in this scenario can be found in section 4.2.29.5. This problem is characterized as "due to surveillance deficiencies" and is not attributed to the TIS software.

4.2.19 TEST: Track File, Sector List, Magnetic Deviation Angle SAP, TIS Tracker, and Range Encoding.

4.2.19.1 Test Objective / Criteria.

The objective of this test is to verify that TIS maintains a separate track file; that each TIS track is on a sector list according to current azimuth and the tracker links tracks on the sector lists. Also, that TIS uses a TIS Magnetic Deviation Angle SAP to uplink the magnetic North-corrected own-aircraft ground-track field; that the TIS tracker attaches active tracks to their appropriate sort list and TIS-supported tracks to their appropriate sector list; and that the range encoding for alert aircraft exceeding 30 nmi are correct. The following TVRTM requirements will then be verified: 13, 32, 33, 44, 67, 69 (ote) and 286 (dte).

4.2.19.2 Testing Description.

This test was conducted by running the TISOTLL8 scenario on the ARIES while collecting Mode S data extractions. The scenario includes one TIS client and one intruder aircraft on an Overtaking course, at Level flight, starting 8 miles from sensor and was successfully run to completion. This scenario was also run with the TIS Magnetic Deviation Angle SAP set to zero for comparison of data associated with that SAP (requirement 44).

4.2.19.3 Data Collection and Analysis.

The data extraction files were collected with data types shown in section 4.2.2 at the Mode S using file names MOTLL81.723 and MOTLL8A1.724.

The TIS Tracker/Alert analysis tool was used to calculate tracker and alert data which was compared to the data recorded during the test and the DR TIS List program was used to list the TIS alerts sent in roll call messages. Data collected from the second run with TIS Magnetic Deviation Angle set to zero was analyzed and compared to the data from the first run. Also, the TIS Analysis tool was used on the test data so that the results could be looked at to ensure proper operation of the scenario.
The analysis output files generated were TOTLL81.723 from TIS Analysis, QOTLL81T from the TIS Tracker tool and LSTOTLL8.723 from the TIS list program. Also, the output files from the scenario run with the Magnetic Deviation Angle set to zero were TOTLL8A1.724 from TIS Analysis and LSTOTLL8.724 from the TIS list program.

4.2.19.4 Results / Discussion.

Each TIS track was looked at to prove that it was sorted, computed, and linked correctly. Two runs of the scenario were analyzed to ensure that the TIS Magnetic Deviation SAP has the proper effect on TIS tracking. It was also checked that at more than 30 miles from the sensor the range encoding is collapsed to account for increased cross-range error. The following TIS requirements were verified as a result of data analysis on the TISOTLL8 scenario: 13, 32, 33, 44, 67, 69, and 286.

4.2.19.5 Conclusions.

All TIS requirements associated with this test have been completely verified. There are no outstanding or new points of concern.

4.2.20 TEST: Tracker Operation During Coasts and Altitude State.

4.2.20.1 Test Objective / Criteria.

The objective of this test is to verify the correct operation of data extraction for coasts and drops; that the interface works correctly between the sensor and the TIS tracker for coasts and drops; that if an ATCRBS message is a coast or drop ZR is set to the TIS tracks vertical position or to the lesser of 0.5 nmi and one-half of the tracks range; that track firmness is updated for ATCRBS messages; that for coasts the TIS tracks vertical position is set to 'coast alt' and no further processing is done; that if the TIS tracks altitude state is TREND and the value of the tracks altitude residual is > 105 feet, then the reset smoothing procedure is performed; and that if either track lacks a clear altitude value then dz = dalt = 0. The following TVRTM requirements will then be verified: 114.5, 121 (ote) and 82, 93, 97, 155, 160, 210 (dte).

4.2.20.2 Testing Description.

This test was conducted by running the TISHCSP4 and TISHCSPX scenarios on the ARIES while collecting Mode S data extractions. The TISHCSP4 scenario includes one TIS client and one intruder aircraft on a Head-On course, Climbing flight, starting 45 miles from sensor with a loss of client and intruder beacon information to create track coasts and track drops. The scenario was run to a successful completion. The TISHCSPX scenario includes one TIS client and one intruder aircraft on a Head-On course, Climbing flight, starting 45 miles from sensor with a loss of client and intruder altitude information to create track coasts and track drops. The scenario was run to a successful completion.

4.2.20.3 Data Collection and Analysis.

The data extraction files were collected with data types shown in section 4.2.2 at the Mode S using file names MHCSP41.723 and MHCSPX1.723.

The TIS Tracker/Alert analysis tool was used to calculate tracker and alert data which was compared to the data recorded during the test and the DR TIS List program was used to list the TIS alerts sent in roll call messages. Also, the TIS Analysis tool was used on the test data so that the results could be looked at to ensure proper operation of the scenario, and the RBAT Surveillance File Analysis tool was used to ensure proper operation with track coasts and drops. The analysis output files generated from the TISHCSP4 scenario were THCSP41.723 from TIS Analysis, QHCSP4T.723 from the TIS Tracker tool, QHCSP4A.723 from the TIS Alert tool, LSTHCSP4.723 from the TIS list program, and SFHCSP41.723, SFHCSP42.723, and SFHCSP43.723 from RBAT Surveillance file analysis. The analysis output files generated from the TISHCSPX scenario were THCSPX1.723 from TIS Analysis, QHCSPXT.723 from the TIS Tracker tool, LSTHCSPX.723 from the TIS list program, and SFHCSPX1.723, SFHCSPX2.723, and SFHCSPX3.723 from RBAT Surveillance file analysis.

4.2.20.4 Results / Discussion.

The data collection files were checked to verify that the aircraft whose altitude was not clear level are considered out of coverage. All tracker tasks associated with coasts and drops were verified for correctness. For ATCRBS coasts and drops ZR and TIS track firmness were checked. Also, TIS track Reset Smoothing was determined to work correctly. The following TIS requirements were verified as a result of data analysis on the TISHCSP4 and TISHCSPX scenarios: 82, 93, 97, 114.5, 121, 155, 160, and 210.

The following reliability results were obtained from TIS Analysis for the TISHCSPX data of that scenario. A description of the results listed is shown in appendix D.

Mode S Client	Id	Traffic Advisory Size	Traffic Advisory Rel	Traffic Advisory Size	FAlrm	Proximity Advisory Size	Proximity Advisory Rel	Proximity Advisory Size
1	faa001	12	100.0	12	0.0	47	100.0	47
TOTAL		12	100.0	12	0.0	47	100.0	47

FAlrm	Reliability Size	Bear	Size	Range	Alt	ARate	Head	Stat
0.0	54	100.0	59	100.0	94.9	89.8	100.0	96.6
0.0	54	100.0	59	100.0	94.9	89.8	100.0	96.6

Note that the Altitude Rate is less than the 90 percent reliability requirement. This occurs because there are missing ATCRBS reports and a garbled ID. Therefore, the altitude input for the summary report is lacking some data.

4.2.20.5 Conclusions.

All TIS requirements associated with this test have been completely verified.

The low altitude rate problem can be linked to the "Terra fix" problem as discussed in section 4.2.29.5. This problem is characterized as "due to surveillance deficiencies" and is not attributed to the TIS software.

4.2.21 TEST: Altitude Rate Threshold.

4.2.21.1 Test Objective / Criteria.

The objective of this test is to verify that an altitude change rate of less than 500 feet per minute will be classified as level flight. The following TVRTM requirements will then be verified: 290 ote).

4.2.21.2 Testing Description.

This test was conducted by running the TISHCSP8 and TISHDSP8 scenarios on the ARIES while collecting Mode S data extractions. The TISHCSP8 scenario includes one TIS client and one intruder aircraft on a Head-On course, a Climbing flight, starting 8 miles from sensor and was run to completion with the climb rate of the intruder aircraft at 400 feet per minute. The TISHDSP8 scenario includes one TIS client and one intruder aircraft on a Head-On course, a Descending flight, starting 8 miles from sensor and was run to completion with the descent rate of the intruder aircraft at due to loss of altitude 400 feet per minute.

4.2.21.3 Data Collection and Analysis.

The data extraction files were collected with data types shown in section 4.2.2 at the Mode S using file names MHCSP81.723 and MHDSP81.723.

The TIS Tracker/Alert analysis tool was used to calculate tracker and alert data which was compared to the data recorded during the test and the DR TIS List program was used to list the TIS alerts sent in roll call messages. Also, the TIS Analysis tool was used on the test data so that the results could be looked at to ensure proper operation of the scenario.
The analysis output files generated were THCSP81.723 from TIS Analysis for the TISHCSP8 scenario, and THDSP81.723 from TIS Analysis for the TISHDSP8 scenario.

4.2.21.4 Results / Discussion.

The data collection files were checked to ensure that the altitude rates above 500 feet per minute were used and those below were not. The following TIS requirement was verified as a result of data analysis on the TISHCSP8 and TISHDSP8 scenarios: 290.

4.2.21.5 Conclusions.

All TIS requirements associated with this test have been completely verified. There are no outstanding or new points of concern.

4.2.22 TEST: Sort Bin Linkage Update.

4.2.22.1 Test Objective / Criteria.

The objective of this test is to verify that with a track state of THIRD or MATURE and a change in speed classification or if the track has moved from one bin to another, then the sort bin linkages are updated. The following TVRTM requirement will then be verified: 138, 152 (dte).

4.2.22.2 Testing Description.

This test was conducted by running the TISHLSP4 scenario on the ARIES while collecting a Mode S data extraction. The scenario includes one TIS client and one intruder aircraft on a Head-On course, at Level flight, starting 45 miles from sensor and was run to completion with the speed of the intruder aircraft increasing to 280 knots during the scenario.

4.2.22.3 Data Collection and Analysis.

The data extraction file was collected with data types shown in section 4.2.2 at the Mode S using file name MHLSP4R2.818.

The TIS Tracker/Alert analysis tool was used to calculate tracker and alert data which was compared to the data recorded during the test and the DR TIS List program was used to list the TIS alerts sent in roll call messages. Also, the TIS Analysis tool was used on the test data so that the results could be looked at to ensure proper operation of the scenario.
The analysis output files generated were THLSP4R2.818 from TIS Analysis and QHLSP4T.723 from the TIS Tracker tool.

4.2.22.4 Results / Discussion.

The data collection file was checked to verify that when a track's horizontal speed changes, then the updates continue unaffected. The following TIS requirement was verified as a result of data analysis on the TISHLSP4 scenario: 138, 152.

4.2.22.5 Conclusions.

All TIS requirements associated with this test have been completely verified. There are no outstanding or new points of concern.

4.2.23 TEST: TIS Client Speed Increase Sort Bin.

4.2.23.1 Test Objective / Criteria.

The objective of this test is to verify that a search is anchored at the sort bin list that contains the input TIS track, and a fast search tests the TIS tracks at the input track's sort bin and the eight neighboring ones. The following TVRTM requirements will then be verified: 194, 195 (dte).

4.2.23.2 Testing Description.

This test was conducted by running the TISHLSP8 scenario on the ARIES while collecting a Mode S data extraction. The scenario includes one TIS client and one intruder aircraft on a Head-On course, a Level flight, starting 8 miles from sensor and was run to completion with the client's speed increasing to 280 knots.

4.2.23.3 Data Collection and Analysis.

The data extraction file was collected with data types shown in section 4.2.2 at the Mode S using file name MHLSP81.723.

The TIS Tracker/Alert analysis tool was used to calculate tracker and alert data which was compared to the data recorded during the test and the DR TIS List program was used to list the TIS alerts sent in roll call messages. Also, the TIS Analysis tool was used on the test data so that the results could be looked at to ensure proper operation of the scenario.
The analysis output files generated were THLSP81.723 from TIS Analysis and QHLSP8T.723 from the TIS Tracker tool.

4.2.23.4 Results / Discussion.

All TIS tracks were checked to make sure that they were sorted according to the track speed, fast or slow. The following TIS requirements were verified as a result of data analysis on the TISHLSP8 scenario: 194 and 195.

4.2.23.5 Conclusions.

All TIS requirements associated with this test have been completely verified. There are no outstanding or new points of concern.

4.2.24 TEST: TERRA and Non-TERRA Mode.

4.2.24.1 Test Objective / Criteria.

The objective of this test is to verify that for each ATCRBS message the tracker task updates the TIS track and sort bin linkages; for Terra mode, only ATCRBS tracks are sent to alert determination; when not in Terra mode both ATCRBS and Mode S tracks are sent to alert determination; and for Terra mode, only ATCRBS tracks from the TIS track file are considered for potential alerts. The following TVRTM requirements will then be verified: 88, 126, 200, 201, 205 (ote).

4.2.24.2 Testing Description.

These tests were conducted by running the TIS200 and NON200 scenarios on the ARIES, with Terra and Non-Terra mode in effect, and collecting Mode S data extractions. TIS200 has 150 ATCRBS targets and 50 TIS client aircraft flying in close proximity to each other.

a. The Non-Terra scenario was run with Terra mode off to collect data for the Non-Terra requirements.

4.2.24.3 Data Collection and Analysis.

The data extraction files were collected with data types shown in section 4.2.2 at the Mode S using file names M2002.729 and MN2001.724.

The TIS Tracker/Alert analysis tool was used to calculate tracker and alert data, which was compared to the data, recorded during the test. The DR TIS List program was used to list the TIS alerts sent in roll call messages and see if they were from ATCRBS or Mode S tracks. Also, the TIS Analysis tool was used on the test data so that the results could be looked at to ensure proper operation of the scenario.
The analysis output files generated were T2002.729 from TIS Analysis for the Terra run, and TN2001.724 from TIS Analysis for the Non-Terra run.

4.2.24.4 Results / Discussion.

The horizontal tracker update period was checked for correct operation. Also it was shown that with Terra mode in effect, only ATCRBS tracks were used by TIS and with Terra mode not in effect, both ATCRBS and Mode S tracks were used by TIS for alert determination. The following TIS requirements were verified as a result of data analysis on the TIS200 and NON200 scenarios: 88, 126, 200, 201, and 205.

The following reliability results were obtained from TIS Analysis for the Terra run of the scenario. A description of the results listed is shown in appendix D.

Mode S	----Traffic Advisory---				---Proximity Advisory--		
Client Id	Size	Rel	Size	FAlrm	Size	Rel	Size
TOTAL	1711	90.0	1839	16.3	23101	99.6	23060

	------------------Reliability------------------							
FAlrm	Size	Bear	Size	Range	Alt	ARate	Head	Stat
0.2	24374	90.8	24543	99.3	97.5	23.9	98.4	98.9

The following reliability results were obtained from TIS Analysis for the Non-Terra run of the scenario:

Mode S	----Traffic Advisory---				---Proximity Advisory--		
Client Id	Size	Rel	Size	FAlrm	Size	Rel	Size
TOTAL	1618	100.0	1618	0.0	23488	99.9	23510

	------------------Reliability------------------							
FAlrm	Size	Bear	Size	Range	Alt	ARate	Head	Stat
0.1	25014	92.9	25094	99.8	99.9	27.1	99.9	99.6

Note the increase in reliability of the Non-Terra version over the Terra version.

4.2.24.5 Conclusions.

All TIS requirements associated with this test have been completely verified.
The Non-Terra version of the scenario produced better results. The reason for this is discussed in section 4.2.29.5.

4.2.25 TEST: TIS Service Request and SAP.

4.2.25.1 Test Objective / Criteria.

The objective of this test is to verify that requests for TIS service are handled correctly; that the TIS SAPs can be accessed and changed; that goodbye messages are recognized and processed correctly including those for the zenith cone; that TIS keep-alive messages are sent correctly; and that the message fields for keep-alive and goodbye messages are formatted correctly. Also, that ATCRBS track drops are handled correctly; that Mode S messages, including track drops, are handled correctly; that horizontal track updates for horizontal track states of FIRST and SECOND are initialized and computed correctly. Verify that the above functions occurred by analysis of the Data Extractions. The following TVRTM requirements will then be verified: 20, 34, 36-38, 41-43, 81, 113-117, 249, 250, 257, 263, 269, 273, 295, 298-300 (ote) and 89, 106-108, 129-135 (dte).

4.2.25.2 Testing Description.

These tests were conducted by running the TIS4411S scenario on the ARIES and collecting Mode S data extractions. The TIS4411S scenario contains six client aircraft that fly into or out of TIS coverage to verify the requirements as follows:

a. Before running the scenario, on the Local Maintenance Terminal, verify all TIS SAPs are installed on sensor and that the SAP values are correctly set. (34, 41, 43)

b. One run was with all the SAP values set to the default settings for the following requirements: (20, 42, 81, 89,106-108, 113, 114, 117, 129-135, 249, 250, 257, 263, 269, 273, 295, 298, 299, 300)

c. One run was with the TIS Enable/Disable SAP disabled to test that no TIS processing will take place during this condition. (36, 37, 38)

d. One run was with the Zenith Cone Angle changed from the default setting to 70 to ensure that settings can be changed and that "goodbye" messages are sent at the correct times. (115, 116)

4.2.25.3 Data Collection and Analysis.

The data extraction files were collected with data types shown in section 4.2.2 at the Mode S using file names M44111.725, M44112.725, M44113.725, and M4411S1.724.

The TIS Tracker/Alert analysis tool was used to calculate tracker and alert data that was compared to the data recorded during the test. The DR TIS List program was used to list the TIS alerts sent in roll call messages and to list the uplink and downlink messages sent to and received from the TIS aircraft as it flies into, through, and out of the zenith cone and while entering and exiting the sensor coverage area.
Also, the TIS Analysis tool was used on the test data so that the results could be looked at to ensure proper operation of the scenario.
The analysis output files generated were T44111.725, T44112.725, T44113.725, and T4411S1.724 from TIS Analysis, Q44111T.725 from the TIS Tracker tool, and LST44111.725 from the TIS list program.

4.2.25.4 Results / Discussion.

All TIS SAP's were tested to ensure that they could be changed to the correct values. The output with the TIS flag disabled was reviewed to see that TIS did not operate. When the Zenith Cone Angle was changed the output was checked to see that the targets went into it at the proper time. Goodbye messages for aircraft going out of coverage or into the zenith cone were checked for, including looking for message type 62 and the remainder of the message set to zero. Keep-alive messages were seen to occur at the proper time. The value of the TIS message type field was checked for correctness. Dropped tracks were removed correctly from TIS tracking. Also, horizontal tracking through the first and second track updates was checked for correct operation of all tracker fields. The following TIS requirements were verified as a result of data analysis on the TIS4411S scenario: 20, 34, 36-38, 41-43, 81, 89, 106-108, 113-117, 129-135, 249, 250, 257, 263, 269, 273, 295, and 298-300.

4.2.25.5 Conclusions.

All TIS requirements associated with this test have been completely verified. There are no outstanding or new points of concern.

4.2.26 TEST: Self-Alert, Mature TIS Track and Uplink Message.

4.2.26.1 Test Objective / Criteria.

The objective of this test is to verify that the client track does not self-alert; that MATURE TIS tracks are evaluated for alert generation; and that alerts on the input list which have equal ranges are then sorted by time. Also, that TIS uplink messages may contain one or two alerts; that the message type field indicates the correct type; and that the Traffic Information Block contains the following fields: Traffic Bearing, Traffic Range, Relative Altitude, Altitude Rate Traffic Heading, and Traffic Status. The following TVRTM requirements will then be verified: 198, 199 (dte) and 261, 263, 274 (ote).

4.2.26.2 Testing Description.

This test was conducted by running the TIS4421 scenario on the ARIES while collecting a Mode S data extraction. The scenario includes one TIS client flying outbound on a radial situated between two intruder aircraft flying one degree to the left and right, and the scenario was run to completion without any special conditions set.

4.2.26.3 Data Collection and Analysis.

The data extraction file was collected with data types shown in section 4.2.2 at the Mode S using file name M44211.722.

The TIS Tracker/Alert analysis tool was used to calculate tracker and alert data which was compared to the data recorded during the test, and the DR TIS List program was used to list the TIS alerts sent in roll call messages. Also, the TIS Analysis tool was used on the test data so that the results could be looked at to ensure proper operation of the scenario.
The analysis output files generated were T44211.722 from TIS Analysis, Q4421T.722 from the TIS Tracker tool, Q4421A.722 from the TIS Alert tool, and LST4421.722 from the TIS list program.

4.2.26.4 Results / Discussion.

The TIS tracker output file was checked to make sure that no self-alerts were generated. All non-mature tracks did not generate traffic alerts. Each TIS uplink message contained information on only one or two traffic alerts. The TIS traffic data message was checked for the correct message type and the correct information in the Traffic Information Blocks. The following TIS requirements were verified as a result of data analysis on the TIS4421 scenario: 198, 199, 261, 263, and 274.

4.2.26.5 Conclusions.

All TIS requirements associated with this test have been completely verified. There are no outstanding or new points of concern.

4.2.27 TEST: Alert Generation and Message Type.

4.2.27.1 Test Objective / Criteria.

The objective of this test is to verify that each TIS track is tested for alert generation; that there are two categories of alerts (proximity and threat); and that the alert lists contain determination taus and square of the range between the input TIS track and the track generating the alert. Also, to be tested is that the alert processing shall generate prioritized alert lists in the correct format to be uplinked to client aircraft. Testing will show that all types of messages are generated and that the last message in the group has a message type of 61. The following TVRTM requirements will then be verified: 186-189, 271 (ote) and 196, 197 (dte).

4.2.27.2 Testing Description.

This test was conducted by running the TIS4422 scenario on the ARIES while collecting a Mode S data extraction. The scenario contains three groups of five targets, each containing one TIS client with four intruders causing proximate and traffic advisories. The three groups differ by the number of traffic advisories versus the number of proximate advisories, 1 to 3, 2 to 2, and 3 to 1. The clients all fly outbound, on a radial, and the intruders also fly outbound, sometimes on the same radial but at a different altitude and sometimes on a radial 1° to the right or left of the client. The scenario was run to completion without any special conditions set.

4.2.27.3 Data Collection and Analysis.

The data extraction file was collected with data types shown in section 4.2.2 at the Mode S using file name M44221.722.

The TIS Tracker/Alert analysis tool was used to calculate tracker and alert data which was compared to the data recorded during the test and the DR TIS List program was used to list the TIS alerts sent in roll call messages. Also, the TIS Analysis tool was used on the test data so that the results could be looked at to ensure proper operation of the scenario.
The analysis output files generated were T44221.722 from TIS Analysis, Q4422A.722 from the TIS Alert tool, and LST4422.722 from the TIS list program.

4.2.27.4 Results / Discussion.

All TIS alerts are generated correctly and determined to be either a proximity or threat. The alerts were sent to the client aircraft in priority order. Messages other than traffic alerts (i.e., goodbye and keep-alive) are also sent to the client. Also, it was determined that the final TIS alert message in a group has a message type set to 61. The following TIS requirements were verified as a result of data analysis on the TIS4422 scenario: 186 – 189, 196, 197, and 271.

Analysis of the data for this scenario showed that self-alerts had occurred for two of the three clients. Self-alerts happened three times for client ATCRBS ID 0001 and twice for client ATCRBS ID 0006. These self-alerts were a result of coasting conditions caused by code swaps with the altitude confidence dropping to zero. RBAT Surveillance Print analysis was used for this with output files of SP44221.722 and SP44226.722.

The following reliability results were obtained from TIS Analysis for the data of the scenario. A description of the results listed is shown in appendix D.

Mode S		----Traffic Advisory---				---Proximity Advisory		
Client	Id	Size	Rel	Size	FAlrm	Size	Rel	Size
1	faa001	120	95.8	117	1.7	403	97.3	392
2	faa006	279	97.8	278	1.8	245	98.0	240
3	faa00b	428	96.7	414	0.0	116	92.2	107
TOTAL		827	97.0	809	0.9	764	96.7	739

	------------------Reliability------------------							
FAlrm	Size	Bear	Size	Range	Alt	ARate	Head	Stat
0.0	507	90.3	507	99.2	96.4	87.4	99.2	97.0
0.0	513	83.2	513	99.2	90.3	89.1	98.1	96.7
0.0	521	84.1	521	98.8	95.8	93.5	97.3	97.3
0.0	1541	85.9	1541	99.1	94.2	90.0	98.2	97.0

Note that the bearing reliability is below the 90 percent success rate. This can be attributed to the "Terra fix" problem discussed in section 4.2.29.5.

4.2.27.5 Conclusions.

All TIS requirements associated with this test have been completely verified.

An explanation for the cause and affect of the self-alert found in this test can be found in section 4.2.29.5.

4.2.28 TEST: Alert Sorting, Prioritizing and Message Type.

4.2.28.1 Test Objective / Criteria.

The objective of this test is to verify the alerts are sorted, then prioritized by increasing range within the proximity and threat lists. Also, that individual alert messages are grouped by "Number of Traffic Aircraft" and "Structure of Group", and that if a TIS alert message is an intermediate message in the group the message type field shall be set to the value 60. The following TVRTM requirements will then be verified: 236, 237 (dte) and 231-233, 262, 270 (ote).

4.2.28.2 Testing Description.

This test was conducted by running the TIS4423 scenario on the ARIES while collecting a Mode S data extraction. The scenario includes one TIS client and eight intruder aircraft; four of the intruders will generate proximate advisories and four of the intruders will generate traffic advisories. The scenario was run to completion without any special conditions set.

A Non-Terra run was also made with the scenario NON4423 to assist in priority ordering process verification.

4.2.28.3 Data Collection and Analysis.

The data extraction files were collected with data types shown in section 4.2.2 at the Mode S using file names M44231.722 and MN44231.724.

The TIS Tracker/Alert analysis tool was used to calculate tracker and alert data which was compared to the data recorded during the test and the DR TIS List program was used to list the TIS alerts sent in roll call messages. Also, the TIS Analysis tool was used on the test data so that the results could be looked at to ensure proper operation of the scenario.
The analysis output files generated were T44231.722 from TIS Analysis, Q4423T.722 from the TIS Tracker tool and LST4423.722 from the TIS list program.

4.2.28.4 Results / Discussion.

All alerts sent to client aircraft were checked to make sure that alert priority ordering (by increasing range separation) takes place. This was done for the Terra as well as the Non-Terra runs. If the range separation of two alerts is equal then the earlier occurring alert is sent first. It was confirmed that individual alert messages are grouped by Number of Traffic Aircraft and Structure of Group. Also, for intermediate TIS alert messages it was shown that the message type field was set to the value of 60.
The following TIS requirements were verified as a result of data analysis on the TIS4423 scenario: 231-233, 236, 237, 262, and 270.

During the analysis of the results it was noted that there were not always eight intruders being sent to the client even though there were always eight of them appearing in the scenario. RBAT Surveillance Print analysis showed this to be caused by the fact that ATCRBS ID 0002 had its altitude jump to 92500 feet and later to drop to 0 feet. These altitudes did not cause a conflict and therefore this intruder did not show up as an alert at these times. Also, ATCRBS ID 0005 had its altitude drop to 0 feet causing it to be dropped as an intruder at that time.

Self-alerts occurred on two separate occasions during this scenario. The first happened because the client ID developed a range difference of 0.36 nmi during a portion of the scenario. The other self-alert occurred when then client ID developed an altitude difference of up to 500 feet during the scenario. In both cases, when the differences receded to minimal values, the self-alerts disappeared. Analysis of the data showed that code swaps occurred to cause these discrepancies. The RBAT Surveillance Print program was used for this with the output file of SP4423SA.722.

The results from the analysis of the data for the Non-Terra version of the scenario showed that there were no self-alerts and that all eight intruders were sent to the client as intruders during their appearance in the scenario. This showed that there were no instances of dropped targets due to garbling or other problems. The Non-Terra output analysis file was TN44231.724 from TIS Analysis.

The following reliability results were obtained from TIS Analysis for the Terra run of the scenario. A description of the results listed is shown in appendix D.

Mode S		----Traffic	Advisory---			---Proximity	Advisory	
Client	Id	Size	Rel	Size	FAlrm	Size	Rel	Size
1	faa001	460	95.0	445	1.8	576	99.1	573
TOTAL		460	95.0	445	1.8	576	99.1	573

	--------	--------	----Reliability	----	--------	--------	--------	--------
FAlrm	Size	Bear	Size	Range	Alt	ARate	Head	Stat
0.3	1008	83.1	1008	95.9	97.4	95.4	93.8	97.1
0.3	1008	83.1	1008	95.9	97.4	95.4	93.8	97.1

Note the bearing reliability of 83.1 percent is below the 90 percent mark set in the guidelines.

The following reliability results were obtained from TIS Analysis for the Non-Terra run of the scenario:

Mode S		----Traffic	Advisory---			---Proximity	Advisory	
Client	Id	Size	Rel	Size	FAlrm	Size	Rel	Size
1	faa001	585	100.0	585	0.0	576	100.0	576
TOTAL		585	100.0	585	0.0	576	100.0	576

	--------	--------	----Reliability	----	--------	--------	--------	--------
FAlrm	Size	Bear	Size	Range	Alt	ARate	Head	Stat
0.0	1161	94.7	1161	100.0	100.0	100.0	100.0	100.0
0.0	1161	94.7	1161	100.0	100.0	100.0	100.0	100.0

The reliability is acceptable in all instances for the Non-Terra version of the scenario.

4.2.28.5 Conclusions.

All TIS requirements associated with this test have been completely verified.

The self-alerts and the dropping of intruder information can be traced to two problems that occurred during scenario and live flight testing. The self-alerts occur when TIS mistakenly identifies the client's own aircraft as an intruder and sends an alert message. This problem is a result of the Mode S sensor temporary "Terra fix." The "Terra fix" was implemented to detect defective transponders manufactured by the Terra Corporation. In "Terra" mode, both a Mode S and ATCRBS track are generated for each Mode S target. Occasionally, when garbling or poor detection has occurred, TIS mistakenly identifies this ATCRBS track as an intruder (to the client

Mode S track), and sends an advisory message to the client, which is shown on the TIS display as being directly on top of the client. This additional ATCRBS target report, resulting from the garbling condition, is also part of the normal ATC disseminated surveillance data.
The dropped intruder information occurred because of the "Terra fix" problem and because of a Mode S altitude detection problem. Occasionally, for some unexplained reason, the Mode S would falsely report an aircraft's altitude at some extremely large value (i.e., 92,500 feet) for one scan, and then return it back to normal the following scans. However, this inaccurate reporting of altitude for ATCRBS targets did result in TIS dropping intruders, as was the case in this scenario. It should be noted that neither one of these problems is TIS based and the TIS software does not need to be fixed to correct them.

Note that since there were no problems encountered with the Non-Terra run of the scenario, all discrepancies can be traced back to the "Terra fix" thereby verifying the TIS programming.

4.2.29 TEST: Maximum Alert List Message Processing.

4.2.29.1 Test Objective / Criteria.

The objective of this test is to verify the maximum number of eight alerts in an alert output list; that the proximity alerts are added to the lists when there are less than eight threat alerts; and that the output lists are sent to the TIS message formation processing. The following TVRTM requirements will then be verified: 234, 235, 239, 260 (ote).

4.2.29.2 Testing Description.

This test was conducted by running the TIS4424 scenario on the ARIES while collecting a Mode S data extraction. The scenario includes 1 TIS client and 12 intruder aircraft. The 12 intruders will fly so as to cause 12 advisories to be generated at 1 time and the scenario was run to completion without any special conditions set.

a. A Non-Terra run was also made with the scenario NON4424 to assist in priority ordering process verification.

4.2.29.3 Data Collection and Analysis.

The data extraction files were collected with data types shown in section 4.2.2 at the Mode S using file names M44241.722 and MN44241.724.

The TIS Tracker/Alert analysis tool was used to calculate tracker and alert data which was compared to the data recorded during the test, and the DR TIS List program was used to list the TIS alerts sent in roll call messages. Also, the TIS Analysis tool was used on the test data so that the results could be looked at to ensure proper operation of the scenario.
The analysis output files generated were T44241.722 from TIS Analysis, Q4424T.722 from the TIS Tracker tool, and LST4424.722 from the TIS list program.

4.2.29.4 Results / Discussion.

The list of all TIS alerts sent to the client aircraft were reviewed to ensure that a maximum of eight alerts were sent at one time and that they were in priority order from traffic to proximity. The following TIS requirements were verified as a result of data analysis on the TIS4424 scenario: 234, 235, 239, and 260.

During the analysis of the results it was noted that while there were always eight intruders being sent as alerts to the client, they were not always the eight highest in priority ordering as required by the program. RBAT Surveillance Print analysis showed this to be caused by the fact that ATCRBS ID's 0002,0003,0004,0005, and 0007 had their altitude values garble and drop to 0 feet at various times during the scenario. These altitude changes did not cause a conflict and therefore, the intruders did not show up as an alert at these times. When these intruders were coasting and not being considered for alerts, other intruders of the 12 in this scenario were being used to fill in the 8 total alerts being sent to the client. The result of this was that the eight closest in priority intruders were not always being sent to the client.

Self-alerts occurred on two separate occasions during this scenario. The first happened because the client ID developed an azimuth difference of 0.59° during a portion of the scenario. The other self-alert occurred when the client ID developed an altitude difference of 400 feet during the scenario. In both cases, when the differences receded to minimal values, the self-alerts disappeared. Analysis of the data showed that in both cases, the altitude confidence for the self-alerts was zero. In the case of the azimuth difference, the target was coasting. The RBAT Surveillance Print program was used for this analysis and the output file of SP4424SA.722.

The results from the analysis of the data for the Non-Terra version of the scenario showed that there were no self-alerts and that all of the eight closest intruders were sent to the client as alerts during their appearance in the scenario. This showed that there were no instances of dropped targets due to garbling or other problems. The Non-Terra output analysis file was TN44241.724 from TIS Analysis.

The following reliability results were obtained from TIS Analysis for the Terra run of the scenario. A description of the results listed is shown in appendix D.

```
Mode S         ----Traffic Advisory---   ---Proximity Advisory
Client      Id     Size   Rel  Size FAlrm    Size   Rel  Size
     1 faa001       406  98.8   406   1.2     755  97.5   739
TOTAL               406  98.8   406   1.2     755  97.5   739

          -----------------Reliability-----------------
FAlrm     Size  Bear  Size Range   Alt ARate  Head  Stat
  0.4     1137  84.9  1137  97.4  92.2  94.1  96.6  97.4
  0.4     1137  84.9  1137  97.4  92.2  94.1  96.6  97.4
```

The following reliability results were obtained from TIS Analysis for the Non-Terra run of the scenario:

Mode S		----Traffic Advisory---				---Proximity Advisory		
Client	Id	Size	Rel	Size	FAlrm	Size	Rel	Size
1	faa001	499	100.0	499	0.0	637	99.8	637
TOTAL		499	100.0	499	0.0	637	99.8	637

	---------Reliability---------							
Falrm	Size	Bear	Size	Range	Alt	ARate	Head	Stat
0.2	1135	93.6	1135	100.0	100.0	100.0	99.9	98.9
0.2	1135	93.6	1135	100.0	100.0	100.0	99.9	98.9

The reliability is acceptable in all instances for the Non-Terra version of the scenario.

4.2.29.5 Conclusions.

All TIS requirements associated with this test have been completely verified.

The self-alerts and the dropping of intruder information can be traced to two problems that occurred during scenario and live flight testing. The self-alerts occur when TIS mistakenly identifies the client's own aircraft as an intruder and sends an alert message. This problem is a result of the Mode S sensor temporary "Terra fix." The "Terra fix" was implemented to detect defective transponders manufactured by the Terra Corporation. In "Terra" mode, both a Mode S and ATCRBS track are generated for each Mode S target. Occasionally, when garbling or poor detection has occurred, TIS mistakenly identifies this ATCRBS track as an intruder (to the client Mode S track), and sends an advisory message to the client, which is shown on the TIS display as being directly on top of the client. This additional ATCRBS target report, resulting from the garbling condition, is also part of the normal ATC disseminated surveillance data.
The dropped intruder information occurred because of the "Terra fix" problem and because of a Mode S altitude detection problem. Occasionally, for some unexplained reason, the Mode S would falsely report an aircraft's altitude at some extremely large value (i.e., 92,500 feet) for one scan, and then return it back to normal the following scans. However, this inaccurate reporting of altitude for ATCRBS targets did result in TIS dropping intruders, as was the case in this scenario. It should be noted that neither of these problems is TIS based and the TIS software does not need to be fixed to correct them.

Note that since there were no problems encountered with the Non-Terra run of the scenario, all discrepancies can be traced back to the "Terra fix" thereby verifying the TIS programming.

4.2.30 TEST: TIS Aircraft Requesting Service.

4.2.30.1 Test Objective / Criteria.

The objective of this test is to verify the correction operation of the TIS Maximum Aircraft Supported SAP for the maximum number of TIS aircraft requesting service and maximum legal value allowed by sensor. The following TVRTM requirements will then be verified: 39 and 40 (ote).

4.2.30.2 Testing Description.

These tests were conducted by running the UNBRAMP scenario on the ARIES while collecting Mode S data extractions. This scenario starts with 50 TIS clients and then increases the number by 10 every 2 minutes until it reaches 200 TIS clients. The scenario was run multiple times with the SAP values changed as follows:

a. First, the SAP value was manually varied to exceed the value of the TIS Maximum Aircraft Supported SAP to 710. This is an illegal value for this SAP and was rejected. Seven hundred is the maximum legal value for this SAP.
Returned the SAP setting to 50 and ran the scenario to completion.

b. Ran the scenario a second time. Changed the TIS Maximum Aircraft Supported SAP value to 25 when loading SAPs and then ran scenario to completion.

4.2.30.3 Data Collection and Analysis.

The data extraction files were collected with data types shown in section 4.2.2 at the Mode S using file names MUNBRMP1.723 and MUNBRMP2.725.

The TIS Tracker/Alert analysis tool was used to calculate tracker and alert data which was compared to the data recorded during the test and the DR TIS List program was used to list the TIS alerts sent in roll call messages. Also, the TIS Analysis tool was used on the test data so that the results could be looked at to ensure proper operation of the scenario.
The analysis output files generated were TUNBRMP1.723 and TUNBRMP2.725 from TIS Analysis of the two scenario runs.

4.2.30.4 Results / Discussion.

The Maximum Aircraft Supported SAP was verified by changing its value to an illegal value that was not accepted by the program. Then the scenario was run twice at two different SAP values and the output of TIS analysis showed that the number of aircraft actually supported matched the currently used SAP value. The following TIS requirements were verified as a result of data analysis on the TIS4424 scenario: 39 and 40.

4.2.30.5 Conclusions.

All TIS requirements associated with this test have been completely verified. There are no outstanding or new points of concern.

4.3 LIVE WORLD FLIGHT TESTING.

Two FAA Technical Center aircraft (N39 and N49) were used for the live flight tests. Aircraft N39 was equipped with a General Aviation (GA) Mode S transponder (Bendix/King KT-70) with one antenna and was designated as the client. Aircraft N49 was equipped with a commercial Mode S Transponder unit with upper and lower antennas and was designated as the intruder. Both aircraft were equipped with a prototype ADLP and TIS display (PC laptop-based) that was used to simultaneously record and display data sent to each aircraft. Data was also extracted at the Mode S sensor.

A total of 13 different flight events (A through L, and X) consisting of various flight formations, encounters, and maneuvers were conducted, over a 2-day period. A preflight briefing conducted by the lead pilot was held prior to each flight to ensure the team knew the planned event sequence, altitudes, and radio frequencies, etc. This was done to ensure the safety of the test personnel, pilots, and the aircraft while successfully completing all the TIS test events.

Flight test procedures and a flight log book were provided for each aircraft. These procedures contained instructions for setup and use of the PC ADLP and TIS display functions, a complete set of the planned flight events, and file naming conventions, etc. Similarly, a test procedures and log book were provided for the Mode S sensor. It contained scripts that identified which SAP files to use; system hardware setups; data extraction types and file naming conventions, etc. All test activity was logged in the logbooks.

Data analysis was used to evaluate and correlate the live flight data extractions. The RBAT was used to verify the OT&E test requirements. The test team also had log listings from the ADLP/TIS display to review, which included all data transmissions to the aircraft from the Mode S/TIS software.

Formal live flight testing using the SAR214G Mode S image was conducted on July 17 and 18, 1997, with FAA pilots, ACT-310 staff, and contracted personnel. The flights originated from the Technical Center in Atlantic City, NJ. The Mode S sensor (Sensor # 1) is located in building 269 at the Technical Center.

4.3.1 TEST: Live World Flight No.1.

4.3.1.1 Test Objective/Criteria.

The objective of this test is to verify that the TIS tracker receives surveillance inputs, maintains a tracker file, and provides alert messages containing the required data in Comm-A format to the client aircraft. Also, when the sensor is TIS enabled it reads out the contents of a transponder Mode S extended capability register (GICB register 16) during Mode S track acquisition and provides a data extraction file containing the tracker uplink messages and GICB register contents. The following TVRTM requirements will then be verified: 7, 77, 83, 170, 242-246, 259, 308-314, 343, 345 (ote).

4.3.1.2 Testing Description.

The two FAA aircraft, equipped with ADLP and TIS displays, took off and flew 10 flight events during Live Flight No. 1. Although only one aircraft was designated as the client, both aircraft requested TIS service and recorded data for the entire flight.

See appendix B for a complete description (and diagrams) of all live flights events. The aircraft maintained a minimum 300-foot altitude separation during all maneuvers. At one point during the flight, both aircraft requested and discontinued TIS service.

The events completed in the first flight included the following:

A. an overtaking intruder making a 180° turn;

L. an overtaking intruder making a 45° turn;

K. both aircraft flying out of TIS and sensor coverage, then returning;

I. the intruder overtaking the client on the right side from 4 miles out and closing to within 1/4 mile before turning to the right, away from client (flown twice);

J. both aircraft flew through the zenith cone starting at least 5 miles from the sensor (flown twice);

H. the intruder flew an S pattern overtaking the client;

D. the intruder overtaking the client from below on same course and changing altitude;

F. the aircraft flew on a Head-on course.

The Mode S sensor provided TIS alert information to the FAA aircraft, maintained tracks on all aircraft within the TIS's operating range, and recorded the Mode S data extractions. The ADLP/TIS displays recorded messages sent and received by the client aircraft.

4.3.1.3 Data Collection and Analysis Method.

Data files were collected at the Modes S (MTISLIV1.717 and MTISLIV2.717) and on the ADLP/TIS prototype displays (LOGN39a.717, LOGN39b.717, LOGN49.717). The data types collected on the Mode S are listed in section 4.2.2. The ADLPs recorded Comm A messages that were sent to client aircraft and the Comm B messages that were issued by the ADLPs.

The RBAT TIS Analysis program was used to obtain a listing on the TIS client and intruder aircraft that contains time, range, azimuth, altitude, ID codes, and track numbers. The DR TIS List program was used to list the downlink messages sent from the TIS aircraft, which show the message format and other types of information. The DR TIS List program also provided a list of the alert messages to the TIS aircraft. Surveillance Print, Miscellaneous Print RBAT programs and the TIS Tracker/Alert analysis tool were used to list the individual scan data to determine the flag bits that were set or not set; if TIS transponder registers had been read in the correct sequence; and if the selected data types were correctly extracted.

Detailed analysis was necessary to determine the cause of self-alerts, incorrect altitude values, and what the tracker files contained during the "crossover problem." The Surveillance Print, Miscellaneous Print RBAT programs and the TIS Tracker/Alert analysis tool were used to list the individual scan data to compare the client Mode S report values of azimuth, range, altitude, and ID code with the ATCRBS report for the TIS client ID. This detailed analysis enabled the test group to determine that the self-alerts were caused by the Terra algorithm check.

The ADLP display file was played-back and the file listing was reviewed to compare with the Surveillance Print results to verify that the intruder aircraft was incorrectly displayed for the "crossover problem."

4.3.1.4 Results.

Review of the data analysis results verified that the sensor data link provided the downlink request messages to enable and disable TIS service to the client aircraft. When TIS is enabled on the Mode S, local track files are maintained for all surveillance targets (beacon equipped) by TIS which contain time, range, azimuth, altitude, ID codes, track numbers, and flags. TIS tracks that do not indicate a request for TIS service are not linked to a sector list and do not receive further TIS processing. ADLP data extraction file LOGN49.717 and data analysis files MPLIV1RP.717, QLLIV1RP.717, QLV2RP40.717 were used for requirement verification. Note: QLHCSPX.723 was used to verify some of the "altitude_types" that did not occur in the live flight.

The TIS uplink messages, which are Mode S Comm-A's (56-bit format), were listed by the extraction and analysis programs. Within the uplink messages the following bit groups and values have been verified: the first 8-bits contain the MSP header and has the value 02 hexadecimal for all TIS messages; the next 6 bits contain the message type field, and the remainder of the TIS uplink message contains two 21-bit Traffic Data Blocks. ADLP data extraction file LOGN49.717 and data analysis files TLN39LV1.717, TLN49LV1.717 were used for requirement verification.

The TIS Traffic Alert messages are composed of the 8-bit MSP header, the 6-bit message type field, and two 21-bit Traffic Data Blocks. ADLP data extraction file LOGN49.717 and data analysis files TLN39LV1.717, TLN49LV1.717 were used for requirement verification.

During Mode S track acquisition, in which the TIS SAP is enabled, the contents of the transponder Mode S extended capability register (GICB register 16) were read out. When the MSP bit (bit 25 in the extended capability register) was set (indicating MSP avionics support), TIS set the flag that read the contents of the transponder MSP capability register (GICB register 30) to check whether the aircraft was requesting TIS service. When the flag was set, the sensor requested this register via a ground-initiated Comm-Bs. Data analysis file QLCMV1RC.718 was used for requirement verification, because the correct sequence of evens did not occur during Live Flight No.1.

When the TIS request bit (bit 2) of the MSP capability register was set the TRACK.tis_req_flag was set TRUE upon Mode S track acquisition and a message containing the aircraft's Mode S address and the tis_req flag value was sent to Data Extraction. Data analysis files QLCMV1SF.718 and QLLIV31.717 were used for requirement verification.

When the MSP bit was not set, or when the TIS request bit was not set, then the TRACK.tis_req_flag was set FALSE at Mode S track acquisition and TIS was not provided to that aircraft. ADLP data extraction file LOGN49.717 and data analysis file QLLV2312.717 were used for requirement verification.

When the sensor received a broadcast downlink message, it checked for a TIS Mode S-Specific Protocol message. The first 8 bits were examined to see if the value was 02 hexadecimal, that value identified a TIS Service Connect Request (TSCR) or a TIS Service Disconnect Request (TSDR) was in the Comm B messages. Data analysis files MPLIV191.717, SPLIVGA.717, TN49LIV2.717, and ADLP data extraction file LOGN49.717 were used for requirement verification.

When the restart was the result of a sensor channel switch, the track file was initialized and forced the generation of a goodbye message to all the TIS-requesting aircraft. ADLP data extraction file LOGN49a.718 was used for requirement verification. The Mode S channel switch occurred during Live Flight No. 2.

Analysis printouts were used to verify that the following categories were extracted for TIS: TIS reports that are used as inputs to update the TIS track file; TIS track file entries that are updated by the tracking task; TIS alerts/messages that were uplinked to the TIS requesting aircraft; requests that initiated TIS service via TSCR downlinks; requests that terminated TIS service via TSDR downlinks; and acquisition of aircraft requesting TIS service via the readout of the transponder GICB registers. Data analysis files MPLIVrp.717, TN49LIV2.717, MPLIV191.717, SPLIVGA.717, QLCMV1RC.718, and ADLP data extraction file LOGN49.717 were used for requirement verification.

The following TIS requirements were verified as a result of observations and data analysis on the data extractions during the Live Flight No. 1: 7, 77, 83, 170, 242-246, 259, 308-314, 343, 345.

4.3.1.5 Discussion.

This section includes issues of concern and the status of each of these items:

4.3.1.5.1 Self-Alerts

Self-Alerts occurred when the TIS mistakenly identified the client's own aircraft as an intruder and sent an alert message. The self-alerts are shown as "False Alarms" in the following list of results:

Test Number	Mode S DE File	----Traffic Advisory--- Size	Rel	Size	FAlrm	---Proximity Advisory-- Size	Rel	Size	FAlrm
Flt#1	mtisliv1.717	28	100.0	37	24.3	386	100.0	386	0.0
Flt#1	mtisliv2.717	315	100.0	338	6.8	1095	99.9	1094	0.0

Detailed analysis of the data extraction (DE) files (MTISLIV1.717 and MTISLIV2.717) and ADLP log files (LOGN39a.717, LOGN39b.717, LOGN49.717) indicate that some type of surveillance error occurred at the same timeframe as the self-alerts. The surveillance errors included:

a. Altitude differences between client Mode S and ATCRBS reports occurred 16 times.
b. Range differences between client Mode S and ATCRBS reports occurred six times.
c. Garbled ATCRBS IDs occurred two times.
d. In one case, the ATCRBS altitude exceeded 65,00 feet which is an invalid value for normal Mode S operation.

The self-alerts that occurred during DE MTISLIV1.717 are identified in excerpts from the TIS analysis files TSN39LV1.717 and TSN49LV1.717 which are listed below. A description of the results listed is shown in appendix D.

Time-Of-Day	Range	Azmth	Alt	Head	TisHd	Mds-Id	SFN	T	M	Id	SFN
13:26:20.094	1.3	320.0	900	312.1	327.0	a4806f	144	N	T	0140	31
13:26:24.695	1.5	319.0	900	312.8	327.0	a4806f	144	N	T	0140	31
13:26:33.906	1.9	317.7	1000	314.5	327.0	a4806f	144	N	T	0140	31
13:26:43.133	2.3	317.2	1100	315.9	327.0	a4806f	144	N	T	0140	31
13:26:47.742	2.5	317.0	1100	316.1	327.0	a4806f	144	N	T	0140	31
13:26:52.359	2.7	317.0	1100	315.2	327.0	a4806f	144	N	T	0140	31
13:27:10.828	3.6	316.7	1600	298.4	333.0	a4806f	144	N	T	0140	326
13:27:15.438	3.8	316.0	1900	290.6	327.0	a4806f	144	N	T	0140	326
13:27:15.438	2.8	316.1	1300	309.9	327.0	ac9451	445	N	T	0141	266

The self-alerts occurred between 13:26:20 and 13:27:15, when the FAA aircraft (N39 & N49) were taking off from the Technical Center. The aircraft were on the same radial from the Mode S sensor with N39 (ID 0140) ahead of N49 (ID 0141). Eight of the nine alerts occurred to N39 as the aircraft climbed from 900 feet to 1900 feet in less than a minute. N49 was climbing from 200 feet to 1300 feet during the same period and was between N39 and the Mode S sensor. All of the alerts occurred during the time while both aircraft were on the same radial. Once N39 turned to the left, the alerts ended. Five garbled ranges and three garbled altitudes on the ATCRBS ID 0140 caused the alerts and the one self-alert on N49 was the invalid altitude of 62,500 feet on ID 0141.

Additional self-alerts occurred during DE MTISLIV2.717. They are identified in excerpts from the TIS analysis files TSN39LV2.717 and TSN49LV2.717 which are listed below. A description of the results listed is shown in appendix D.

Time-Of-Day	Range	Azmth	Alt	Head	TisHd	Mds-Id	SFN	T	M	Id	SFN
14:01:37.508	49.4	213.1	6300	34.1	45.0	ac9451	445	N	T	0141	266
14:01:42.125	49.0	213.1	6300	34.0	51.0	ac9451	445	N	T	0141	266
14:01:46.742	48.7	213.1	6300	33.4	51.0	ac9451	445	N	T	0141	266
14:10:32.898	22.6	213.1	6600	33.0	51.0	a4806f	337	N	T	0140	502
14:10:37.516	22.3	213.2	6600	32.5	51.0	a4806f	337	N	T	0140	502
14:10:42.133	22.1	213.2	6600	32.5	51.0	a4806f	337	N	T	0140	502
14:10:46.750	21.9	213.2	6600	33.1	51.0	a4806f	337	N	T	0140	502
14:13:51.406	12.0	213.4	6900	33.9	51.0	a4806f	337	N	T	0140	502
14:20:35.359	11.5	42.3	6600		75.0	a4806f	470	N	T	0140	480
14:34:00.695	28.7	213.8	6600		231.0	a4806f	482	N	T	0140	50
14:35:46.844	35.3	213.9	6900	213.2	231.0	a4806f	482	N	T	0140	50
14:38:00.703	42.1	213.8	5600	215.6	225.0	ac9451	434	N	T	0141	264
14:38:05.320	42.3	213.8	5600	215.6	231.0	ac9451	434	N	T	0141	264
14:44:37.648	46.5	213.8	6900	10.2	39.0	a4806f	463	N	T	0140	217

e. The first occurrence was during Event I at 14:01:37 to 14:01:46 and a range of 49 nmi. As N49 (the intruder), closed on N39 (the client), the self-alerts occurred on N49 when it was turning to fly parallel to N39. There were three garbled altitudes and one garbled ID on ATCRBS ID 0141 (N49).

f. The second occurrence was during Event I at 14:10:32 to 14:10:46 and a range of 22 nmi. The self-alerts occurred when N49 closed on N39 and made a turn to fly parallel to N39. This time the alerts were on N39 (ID 0140) and there were four garbled altitude values.

g. The third occurrence was a self-alert on N39 (ID 0140) at 14:13:51, a garbled altitude value, but there was no event in progress at this time.

h. The fourth occurrence was a self-alert on N39 (ID 0140) at 14:20:35 as the aircraft was making a turn to start a new event. The aircraft antenna turning away from the sensor antenna during this scan may have caused a garbled altitude on ID 0140.

i. The fifth occurrence was at 14:34:00 on N39. A garbled altitude on ID 0140 caused the self-alert and no event was in progress.

j. The sixth occurrence was at 14:35:46 during Event D. Both aircraft were on the same radial from sensor with N49 directly under N39 and climbing at the time the self-alert occurred on N39. A garbled altitude on ID 0140 may have been caused by N49 blocking the signal back to the sensor antenna.

k. The seventh occurrence was self-alerts on N49 at 14:38:00 and 14:38:05. The aircraft were flying away from the sensor on the same radial. No event was in progress at this time. The first self-alert was a result of garbled altitude and ID split of ID 0141. The second self-alert, a garbled range value on the ID 0141.

l. The eighth occurrence was on N39 at 14:44:37 during Event F when N49 was passing under N39. The altitude value for ID 0140 (N39) was garbled for this scan.

These errors in the ATCRBS reports and the self-alerts that are generated by TIS, are a result of the "Terra check." The "Terra fix" was implemented to detect defective transponders manufactured by the Terra Corporation. In "Terra" mode, both a Mode S and ATCRBS track are generated for each Mode S target. Occasionally, when garbling or poor detection has occurred, TIS mistakenly identifies this ATCRBS track as an intruder (to the client Mode S track), and sends an advisory message to the client, which is shown on the TIS display as being directly on top of the client. This additional ATCRBS target report, resulting from the garbling condition, is also part of the normal ATC disseminated surveillance data.

The test group did not generate any new SPR's against the "self-alert" problem because it is a known problem (from the 1995 TIS Demo). The following three SPRs are still open awaiting resolution:

SPR #54	3/14/95 Self-alerts,
SPR #107	Traffic advisory false alarm rate high for scenarios and live flights,
SPR #117	Self-alerts still occur due to the "Terra fix" in Mode S software.

4.3.1.5.2 Altitude Anomaly.

The Altitude Anomaly problem has been identified in other Mode S data collections and during the TIS testing conducted in 1995. There was one occurrence during the Live Flight No. 1 test at 13:27:15. The Mode S falsely reported the client aircraft's altitude at some extremely large value (i.e., 65,200 feet) for two scans, and then returned it back to normal for the following scans. This inaccurate reporting of the altitude for an ATCRBS ID resulted in the TIS generating a self-alert on the ADLP TIS display. This is a Mode S altitude detection problem and is not specific to TIS. The invalid altitudes were also found to occur during the ARIES scenario tests.

The test group did not generate any new SPR's against the "altitude anomoly" because it is a known problem (from 1995 TIS Demo) and the following two SPRs are still open awaiting resolution:

SPR #89	Garbled altitude data is reported with high altitude confidence within the Mode S Surveillance tracking (PTR 04285085V became TE00.1 SPR GV95-15204),
SPR #118	Invalid altitudes cause numerous problems with TIS and surveillance.

4.3.1.5.3 Tracking Anomaly.

The TIS Tracking Anomaly problem was observed on the ADLP during Live Flight No. 1, within 30 nmi range, when a fast maneuvering intruding target flew very close to the client aircraft. This problem was initially observed during a flight test of the TIS OT&E for the Dulles demo in 1995 and is referred to as the "crossover problem." This event (I) was conducted two times during the Live Flight No. 1, once at a range of approximately 50 nmi and at a range of approximately 22 nmi.

At the 50 nmi range, the TIS software overlays the intruder onto the client on the ADLP for the six scans (14:01:23 to 14:01:46) when the tracker data crosses over to the left side of the client.

At the 22 nmi range, the TIS software displays the intruder crossing to the rear of the client and then moving along side. The intruder is displayed to the right of the client for five scans

(14:10:37 to 14:10:55) and then jumps to the left side of the client. The problem has been identified to Massachusetts Institute of Technology Lincoln Laboratories (MITLL). After reviewing the problem, MITLL has stated that it cannot be corrected due to the tracker algorithm design and the scan update rate of 4 to 5 seconds for the Terminal Mode S system.

The test group did not generate any new SPRs against the "crossover problem" because it is a known problem (from 1995 TIS Demo) and the following two SPRs are still open awaiting resolution:

SPR #71	3/16/95 Crossover Retry Shows N35 on Wrong Side of N50,
SPR#119	Crossover fix didn't work.

NOTE: These two SPRs relate to flight maneuvers at less than 35 nmi.

4.3.1.6 Conclusions.

All the aircraft events/maneuvers from Live Flight No. 1 were completed and the test results are good. All TIS requirements associated with this test have been completely verified. After all the detailed analysis was completed, no major problems were found, although three minor problems have been identified.

4.3.1.6.1 Self-Alerts.

This problem occasionally occurred during the live flight data collections, just as it had during the scenario test runs. Detailed analysis of each of the problem test cases indicate that there was some type of Mode S surveillance problem or failure when this problem occurred (i.e., garbled ATCRBS IDs, garbled altitude values, missing ATCRBS reports). The primary cause of these self-alerts is the Mode S sensor "Terra fix." Until the removal of the "Terra fix" is complete, this will continue to be a problem.

4.3.1.6.2 TIS Tracking Anomaly.

Again, as in the scenario testing and the 1995 TIS Dulles Demo, the live flight "crossover" maneuver created the intruder crossover problem on the TIS display. The intruder aircraft is displayed incorrectly as a result of the limitations of the TIS tracking algorithm. This "crossover problem" must be identified to the General Aviation Pilots since it cannot be corrected. ACT-310 has been notified that there is a change to the Aeronautical Information Manual (AIM) in progress that will include information on the crossover display problem. This change is necessary before TIS can be released to the field for public use.

4.3.1.6.3 Altitude Anomaly.

One minor problem that occurred during the flight testing was a Mode S altitude detection problem, which was not specific to TIS. Occasionally, for some unexplained reason, the Mode S would falsely report an aircraft's altitude at some extremely large value (i.e., 67,000 feet) for one scan, and then return it back to normal the following scans. However, this inaccurate reporting of altitude for ATCRBS targets did result in TIS misplotting intruders on the ADLP/TIS display. The invalid altitudes were also found to occur with the current Mode S fielded baseline software image and with the ARIES scenarios.

4.3.2 TEST: Live World Flight No. 2.

4.3.2.1 Test Objective/Criteria.

The objective of this test is to verify that the input Mode S track is checked to see if it is currently receiving TIS. If it received TIS on previous scans, and is flagged as not receiving TIS currently, then set the appropriate flags. Verify that "keep-alive" messages for a track are generated when TIS service is requested, after the third update and when a channel switch has occurred; that if the aircraft receiving TIS has flown into the zenith cone, then a "goodbye" message is sent; and that alert messages containing the required data are in Comm-A format as they are sent to the client aircraft. Also, that the TIS Comm-B message containing the Application Identifier Numbers is read, the correct flags are set, and that the downlink message is sent to Data Extraction for analysis. The following TVRTM requirements will then be verified: 109-111, 115, 116, 129, 142, 170, 242-246, 259, 298, 315-321, 321.5 (ote).

4.3.2.2 Testing Description.

The two FAA aircraft, equipped with TIS transponders and ADLP, took off and flew five flight events during Live Flight No. 2. See appendix B for a complete description (and diagrams) of all live flights events. The aircraft maintained a minimum 300-foot altitude separation during all maneuvers. At some point during the flight, the aircraft requested and discontinued TIS service.

The events (maneuvers) for the second flight included the following:

B. the intruder making a 90° crossing pattern behind the client;

C. the intruder making a 90° crossing pattern ahead of the client;

E. at a location 25 miles from sensor, the client started an arc around the sensor and then the intruder flew across the arc;

G. at a location 25 miles from sensor, the client started an arc around the sensor and then the intruder flew on the same arc overtaking the client.

X. the intruder flew directly behind the client in a straight line, starting one-half mile apart. Intruder slows down increasing distance between aircraft to 3 miles, then gradually increase speed to close the gap to within 1 mile.

NOTE: Event X was designed at the pilot briefing meeting on July 18, 1997, to verify that the intruder position on the ADLP was corrected.

The Mode S sensor provided TIS alert information to the FAA aircraft, maintained tracks on all aircraft within the TIS's operating range, and recorded the Mode S data extractions. The ADLP/TIS displays recorded messages sent and received by the client aircraft. A Mode S sensor channel switch was conducted to create a restart of the system and generation of goodbye messages to all aircraft receiving TIS service.

4.3.2.3 Data Collection and Analysis Method.

Data files were collected at the Modes S (MTISLIV1.718, MTISLIV2.718, MTISLIV3.718) and on the ADLP (LOGN39.718, LOGN49a.718, LOGN49b.718). The data types collected on the Mode S are listed in section 4.2.2. The ADLP/TIS prototype displays recorded uplink messages that were sent to and downlink messages that were issued.

The RBAT TIS Analysis program was used to obtain target listing of TIS aircraft which contain time, range, azimuth, altitude, ID codes, and track numbers. The DR TIS List program was used to list the downlink messages sent from the TIS aircraft that contain flags and other types of information. Surveillance Print and Miscellaneous Print RBAT programs, and the TIS Tracker/Alert analysis tool were used for detailed analysis of the test data.

4.3.2.4 Results.

Review of the data analysis results verified that when the input Mode S track is not flagged as currently receiving TIS, the input handler checks whether it was flagged for receiving TIS on the previous update. If the input Mode S track was flagged for receiving TIS on the previous update, and a "goodbye" message was already sent to the aircraft being processed (as indicated by a flag in the TIS track file entry), the processing removes the track being processed from its sector lists and the number of TIS-requesting aircraft is decremented. ADLP data extraction file LOGN49a.718 and data analysis files TNL49LV1.718, MPLIV1RQ.718, QLLIV110.718 were used for requirement verification. Note: "the number of TIS-requesting aircraft is decremented" operation was verified in requirement 106.

When the input Mode S track is not flagged as currently receiving TIS and the "goodbye" message was not sent, the flag in the TIS track is set to indicate that a "goodbye" message should be sent immediately. Data analysis files MPLIV2OC.717, QLOCLV2.717, and QLOCLV2A.717 were used for requirement verification. The out-of-coverage occurred during Live Flight No. 1.

When the input Mode S track update or coast is flagged as currently receiving TIS service, a check was performed to determine if the Mode S aircraft had flown into the zenith cone using the precomputed TIS zenith cone table. When the aircraft receiving TIS service flies into the zenith cone a "goodbye" message was sent. Data analysis files MPLIV2.717 and QL89LV2.717 were used for requirement verification. The Zenith Cone out-of-coverage occurred during Live Flight No. 1.

When the Mode S channel switch occurred, and the TIS track was flagged for TIS service, a "goodbye" message was generated for uplink to aircraft while the sensor TIS software was reinitializing and the horizontal track state was FIRST. ADLP data extraction file LOGN49a.718 was used for requirement verification. The horizontal track state of FIRST could not be shown because the data extraction stopped during the channel switch, but the "goodbye" message was sent so it is assumed that the software worked as described.

When the TIS tracker requesting TIS service had its third update and a sensor channel switch occurs, the track is flagged and a "keep-alive" message is generated. ADLP data extraction file LOGN49a.718 was used for requirement verification. The "third update" could not be shown because the data extraction stopped during the channel switch, but the "keep-alive" message was sent so it is assumed that the software worked as described.

TIS tracks that do not indicate a request for TIS service are not linked to a sector list and do not receive further TIS processing. ADLP data extraction file LOGN49a.718 and data analysis files TNL49LV1.718, MPLIV1RQ.718, QLLIV110.718 were used for requirement verification.

The TIS uplink messages, which are Mode S Comm-A's (56-bit format), were listed by the analysis programs. Within the uplink messages, the following bit groups and values have been verified: the first 8 bits contain the MSP header and has the value 02 hexadecimal for all TIS messages; the next 6 bits contain the message type field, and the remainder of the TIS uplink message contains two 21-bit Traffic Data Blocks. ADLP data extraction file LOGN49a.718 and data analysis files TLN39LV1.718, TLN49LV1.718 were used for requirement verification.

The TIS Traffic Alert messages are composed of the 8-bit MSP header, the 6-bit message type field, and two 21-bit Traffic Data Blocks. ADLP data extraction file LOGN49a.718 and data analysis files TLN39LV1.718, TLN49LV1.718 were used for requirement verification.

The following values were verified with data analysis printouts: Eight-bit Application Identifier Numbers (AINj, j=1 to 6) are read from the TIS Comm B message (TSCR or TSDR) until either of the following occurred: first, AINj = 0 or second, all 56 bits of the downlink message were processed. A request for TIS service (TSCR) was identified by an AIN value of 1. A request to terminate TIS service (TSDR) was identified by an AIN value of 2. ADLP data extraction file LOGN49a.718 and data analysis files TLN39LV1.718, TLN49LV1.718 were used for requirement verification.

When the downlink was a TSCR, then the TRACK.tis_req_flag was set TRUE and a message was sent to Data Extraction containing the aircraft's Mode S address and the value of TRACK.tis_req_flag. ADLP data extraction file LOGN49a.718 and data analysis files MPLIV1RQ.718, QLLV11101.718 were used for requirement verification.

When the downlink was a TSDR, then the TRACK.tis_req_flag was set FALSE and a message was sent to Data Extraction containing the aircraft's Mode S address and the value of FALSE indicating that TIS service was being discontinued to the aircraft being processed. ADLP data extraction file LOGN49a.718 and data analysis files MPLIV1RQ.718, QLLV11101.718 were used for requirement verification.

When the SAP to enable TIS was set, the first interrogation to an aircraft on each scan did not include any Comm-A messages. ADLP data extraction files LOGN39.718, LOGN49a.718, and data analysis files TLN39LV1.718, TLN49LV1.718 were used for requirement verification.

These TIS requirements were verified as a result of observations and data analysis on the data extractions during the Live Flight No. 2: 109-111, 115, 116, 129, 142, 170, 242-246, 259, 298, 315-321, 321.5.

Event X: It was determined during Live Flight No. 1 that the intruders were not being displayed correctly on the prototype TIS display screens. Discussion with technical support personnel at MITLL and ACT-350 agreed with the test group's observations. ACT-350 was able to make a change to TIS display software on the intruder aircraft (N49). In event X, the aircraft flew in a straight line with the lower aircraft (N49) overtaking the upper aircraft (N39) until ahead and then slowing in speed allowing the upper aircraft (N39) to overtake (N49). The ADLP operator in N49 observed that N39 always appeared in the correct reference to N49. Testing of the ADLP software was not part of the requirements to be verified during current TIS testing. The ADLPs provided the test group a means to conduct a complete end-to-end system test. The ADLP hardware and software will have to be formally tested at a later time.

4.3.2.5 Discussion.

This section includes issues of concern and the status of each of these items:

4.3.2.5.1 Self-Alerts.

Self-Alerts also occurred during Live Flight No. 2. The self-alerts are shown as "False Alarms" in the following list of results:

Test	Mode S	----Traffic	Advisory---			---Proximity	Advisory--		
Number	DE File	Size	Rel	Size	FAlrm	Size	Rel	Size	FAlrm
Flt#2	mtisliv1.718	117	99.1	135	14.1	1305	99.2	1295	0.0
Flt#2	mtisliv2.718	0		0		5	100.0	5	0.0
Flt#2	mtisliv3.718	0		0		69	98.6	68	0.0

Detailed analysis of the data extraction (DE) files (MTISLIV1.718, MTISLIV2.718, MTISLIV3.718) and ADLP log files (LOGN39.718, LOGN49a.718, LOGN49b.718) indicate that some type of surveillance error occurred at the same timeframe as the self-alerts. The surveillance errors included:

a. Altitude differences between client Mode S and ATCRBS reports occurred eight times.
b. Range differences between client Mode S and ATCRBS reports occurred eight times.
c. Garbled ATCRBS IDs occurred 12 times.

The self-alerts that occurred during DE MTISLIV1.71 analysis files TSN39LV1.718 and TSN49LV1.718 are listed below. A description of the results listed is shown in appendix D.

Time-Of-Day	Range	Azmth	Alt	Head	TisHd	Mds-Id	SFN	T	M	Id	SFN
10:08:18.711	23.7	222.5	6900	138.5	153.0	a4806f	627	N	T	0256	166
10:09:18.688	24.2	214.4	6600	137.9	153.0	a4806f	627	N	T	0256	166
10:10:23.250	25.4	206.2	6900		153.0	a4806f	627	N	T	0256	166
10:35:01.438	31.8	253.5	6300		183.0	ac9451	227	N	T	0257	184
10:35:06.047	31.8	253.2	6300		183.0	ac9451	227	N	T	0257	184
10:44:34.664	36.1	281.4	6300	269.9	315.0	ac9451	227	N	T	0257	184
10:44:39.289	36.3	281.4	6300	258.5	309.0	ac9451	227	N	T	0257	184
10:45:20.852	37.4	280.0	6600	193.3	201.0	a4806f	627	N	T	0256	166
10:45:57.758	36.9	277.1	6600	145.6	177.0	a4806f	627	N	T	0256	166
10:46:02.375	36.7	276.8	6600	142.4	177.0	a4806f	627	N	T	0256	166
10:46:30.055	35.6	275.2	6900	137.1	153.0	a4806f	627	N	T	0256	166
10:46:34.672	35.4	275.0	6900	137.5	153.0	a4806f	627	N	T	0256	166
10:50:11.469	35.2	251.6	6900	165.2	183.0	a4806f	627	N	T	0256	166
10:50:16.078	35.3	251.0	6900	164.2	183.0	a4806f	627	N	T	0256	166
10:50:16.086	35.2	251.6	6300	163.6	177.0	ac9451	227	N	T	0257	184
10:55:29.898	26.1	224.0	6200	72.1	87.0	ac9451	227	N	T	0257	184
10:55:34.523	25.9	223.7	6200	71.9	87.0	ac9451	227	N	T	0257	184

The following text gives the specific times and ATCRBS deficiencies when the self-alerts occurred during DE file MTISLIV1.718.

d. The first occurrence was during Event B at 10:08:37, a self-alert on N39 (ID 0256), caused by a garbled altitude on ID 0256. A self-alert on N39 at 10:09:18, another garbled altitude on ID 0256 and another alert at 10:10:23 on N39 because of a garbled altitude. None of the alerts can be associated to the maneuvers of the event.

e. The second occurrence was at 10:35:01 and 10:35:06 on N49 (ID 0257). The first alert was a garbled ID (0257) and garbled range. The second was a garbled range difference between the Mode S and ACTRBS reports. There was another aircraft close to N49 and may have caused the garbled reports.

f. The third occurrence was during Event G at 10:44:34 and 10:44:39 on N49 (ID 0257). N49 was making a turn away from sensor when alerts occurred and the antenna may have been blocked. The ATCRBS reports had a garbled ID and range, then a garbled ID, range, and altitude.

g. The fourth occurrence was alerts on N39 during Event G (reverse direction). The alerts occurred at 10:45:20, 10:45:57, 10:46:02, 10:46:30, and 10:46:34 as the aircraft was overtaking N49. The two aircraft were not in close proximity to each other so the ID 0257 ATCRBS report had errors of garbled ID, range, altitude and are unrelated to event maneuvers.

h. The fifth occurrence was at 14:34:00 on N39. A garbled altitude on ID 0140 caused the self-alert and no event was in progress.

i. The sixth occurrence was also during Event G. The alerts occurred at 10:50:11 and 10:50:16 when N39 was passing over N49. The alert was caused by garbled altitude for N39 (ID 0256) at 10:50:11 and a split occurred from ID 0257. The alerts at 10:50:16 were a result of a garbled range for ID 0257 and an ID split for 0256.

j. The seventh occurrence was self-alerts on N49 at 10:55:29 and 10:55:34. The aircraft were flying toward the sensor when the alerts were sent. The first self-alert was a result of a garbled ID and garbled range. The second alert was a result of a garbled range on ATCRBS ID 0257.

4.3.2.6 Conclusions.

All the aircraft events/maneuvers from Live Flight No. 2 were completed and the test results are good. All TIS requirements associated with this test have been completely verified. After all the detailed analysis was completed, no major problems were found, and only one minor problem was identified.

4.3.2.6.1 Self-Alerts.

This problem occasionally occurred during the live flight data collections, just as it had during the scenario test runs. Detailed analysis of each of the problem test cases indicate that there was some type of Mode S surveillance problem or failure when this anomaly occurred (i.e., garbled ATCRBS IDs, garbled altitude values, missing ATCRBS reports). The primary cause of these self-alerts is the Mode S sensor "Terra fix." Until the removal of the "Terra fix" is complete, this will continue to be a problem.

4.4 TEST: REGRESSION TESTING.

The Regression Testing focused primarily on verification of existing Mode S requirements (from Specification FAA-E-2716) and that introduction of TIS into the Mode S baseline did not degrade performance, nor have any negative side effects. The Regression testing was conducted using the Mode S Release Qualification Test (RQT) procedure. The RQT consisted of the following:

a. *RQT Configuration Review (RCR)*: Prior to the start of the RQT, a pretest meeting was held. At this meeting, the test hardware/software configuration was presented, the test team roles and responsibilities were defined, and the pretest issues were discussed.

b. *General Tests:* The general test was the part of the RQT that verified the new hardware/software baseline. The RQT general tests included portions that tested a wide variety of Mode S Sensor functions such as; sensor control, initialization/recovery, sensor status, target handling capacity, sensor stability, and interfaces.

c. *Special Tests:* This test was written specific to this software release, and targeted specific software changes to prove the new functionality. A special test case to test TIS transponder Register 29 was conducted during the RQT.

The RQT and regression testing of TIS register 29 was conducted using SAR214.F image and TISZCONE image on September 22, 1997, at the Technical Center in Atlantic City, NJ.

ACT-310 staff along with contractor personnel conducted the tests. The following tasks: operating the Mode S sensor, operation of the GA transponder, collecting and analyzing data were completed by the test group.

4.4.1 Test Objective/Criteria.

To successfully verify that introduction of TIS into the Mode S baseline does not degrade performance, nor have any negative side effects. Also, that the software change required to the TIS baseline to readout TIS register 29 functions correctly.

4.4.2 Testing Description.

The Regression Test and Mode S RQT were conducted using procedures for the TIS release. The procedures included general Mode S and special TIS tests.

The following scenarios were run to verify that TIS had been successfully added to the SAR214F baseline: TISCRCL8, TISCRDS4, TISHOLL4, TISOTLL8, TIS4424, TIS4411SS, TIS200, and UNBRAMP.

4.4.3 Data Collection and Analysis Method.

Data files were collected at the Modes S (MREG29.922 for regression) and (MCRCL8.922, MCRDS4.922, MHOLL4.922, MOTLL8.922, M4424.922, M4411S, MTIS200, and MUNBRAMP.922). The data types collected on the Mode S are listed in section 4.2.2.

Miscellaneous Print RBAT program and the TIS Tracker/Alert analysis tool were used to obtain a sequence listing and the detailed register content for the regression test data. Also, the TIS Analysis tool was used on the test data so that the results could be looked at to ensure proper operation of the scenario.

Output files TCRCL8.922, TCRDS4.922, THOLL4.922, TOTLL8.922, and T4424.922 were generated from TIS Analysis and used to verify that the scenarios ran correctly. Output files MP4411S.922, MP4411S1.922, and MP4411S3.922 generated from RBAT Miscellaneous Print and LST4411S.922 generated from the TIS list program were used to verify the proper operation of the TIS4411SS scenario.

4.4.4 Results/Discussion.

Data analysis files MP29REG.922 and QL29REG.922 were used for the verification of the Register 29 contents for the regression testing.

It should be noted that the output of scenario TISOTLL8 had a bearing reliability of 81.6 percent and scenario TIS4424 had a bearing reliability of 79.0 percent. The TISOTLL8 low bearing reliability can be traced to numerous self-alerts and the TIS4424 low bearing reliability can be traced to self-alerts and a garbled ID.

4.4.5 Conclusions.

The TIS software worked correctly and the register 29 data was read out. The low bearing reliability discrepancies can be attributed to the Terra fix problem as previously described in this report.

4.5 CPU UTILIZATION.

4.5.1 Test Objective.

The objective of this test was to determine what value the "TIS Maximum Aircraft Supported" SAP should be set to for field deployment. There had not been a specific value recommended for this SAP at the start of TIS testing. A value that limited the maximum CPU utilization for all processors to 80 percent or less, was to be determined.

4.5.2 Testing Description.

A special scenario was developed with the TIS client count starting at 50 and ramping up to 236 (TUC200). The scenario was then run twice on Channel A and twice on Channel B. At each client level increment, the CPU utilization percentage of each on the Mode S processors was recorded. The scenario was allowed to continue until the sensor processors reached 100 percent utilization and the channel under test went to "red" status.

The CPU Utilization test was conducted using SAR214.G TIS DEBUG Mode S image on August 6 and 7, 1997. The tests were performed at the Technical Center in Atlantic City, NJ. The Mode S sensor and the ARIES simulator are located in building 269 at the Technical Center.

ACT-310 staff along with contractor personnel performed the Special testing tasks such as operating the Mode S sensor, technical support, collecting and analyzing data.

4.5.3 Data Collection.

Data collection was completed during the test conduct by entering the CPU utilization percentage values in the procedure tables.

4.5.4 Results.

The following tables contain the results from the TIS client loading test runs, which were conducted to determine a recommended value for the "TIS Maximum Supported" SAP setting.

Table 4.35.4-1 below shows the results from first test run on August 6, 1997. CPU utilization values were collected from Mode S Channel A until the Mode S Channel A status went "red" causing a switch to Channel B. This occurred when the client count had advanced to 218.

TABLE 4.35.4- 1. CHANNEL A CPU UTILIZATION FIRST RUN

	Mode S CPU																			
	0		1		2		3		4		5		6		7		11		13	
Target Load	M ax	C Ur	M ax	C ur	M ax	C ur	M ax	C ur	M ax	C ur	M ax	C ur	M ax	C ur	M ax	C ur	M ax	C ur	M ax	C ur
50	20	14	28	16	10	6	10	4	9	0	13	0	14	4	14	1	4	3	18	15
60	20	15	40	21	11	6	12	4	12	0	14	2	19	5	25	1	6	3	19	12
70	20	14	49	15	12	6	13	4	14	0	14	0	20	5	28	1	6	3	19	12
80	20	15	55	26	13	6	14	4	18	0	14	3	24	5	29	1	7	3	19	14
90	21	20	66	48	14	13	15	12	19	14	12	3	28	23	32	2	6	3	21	17
100	25	21	70	70	15	15	17	15	21	14	13	8	28	25	28	1	7	3	21	17
110	23	21	84	47	18	6	19	4	24	0	16	8	36	6	14	1	7	3	23	15
120	22	14	85	21	18	6	20	4	24	0	17	1	39	6	13	1	6	3	21	12
130	24	16	93	48	20	6	21	4	35	0	19	9	41	6	36	1	7	3	22	15
140	23	21	96	63	20	18	22	20	28	22	17	2	40	36	33	1	6	3	21	18
150	22	14	89	89	21	10	22	7	18	18	10	10	40	8	14	1	4	3	20	18
160	25	14	96	88	23	6	26	4	36	0	15	13	48	7	32	5	7	3	22	13
170	24	14	96	88	23	13	24	11	32	13	12	8	45	13	16	1	4	3	20	20
180	24	23	98	88	23	23	24	24	32	32	15	6	44	44	14	2	4	3	20	20
190	15	14	94	90	11	6	8	4	0	0	11	11	11	7	13	13	3	3	19	13
200	28	26	99	80	25	25	27	26	34	28	22	3	50	49	38	5	9	3	22	19
218																				
236																				

Max value = maximum percentage of CPU utilization indicated for the Target Load sample period
Cur value = percentage of CPU utilization indicated at the sample time for the Target Load

Table 4.35.4-2 below shows the results from second test run on August 6, 1997. CPU utilization values were collected from Mode S Channel A until CPU 1 reached 100 percent. The client count in the scenario had advanced to 218 and the Mode S Channel A status went "red" causing a switch to Channel B. Note: The Mode S status had gone "yellow" during the 200 client level.

TABLE 4.35.4- 2. CHANNEL A CPU UTILIZATION SECOND RUN

	Mode S CPU																			
	0		**1**		**2**		**3**		**4**		**5**		**6**		**7**		**11**		**13**	
Target Load	Max	CUr	Max	Cur	Max	Cur	Max	Cur	Max	Cur	Max	Cur	Max	Cur	Max	Cur	Max	Cur	Max	Cur
50	20	16	27	23	10	7	10	4	19	7	14	3	13	5	15	1	6	3	17	15
60	20	14	36	25	11	6	11	4	12	0	14	4	17	5	26	1	6	3	19	12
70	20	18	47	47	12	12	12	10	14	11	14	5	20	16	25	1	5	3	18	18
80	19	18	54	45	13	12	14	12	15	13	14	2	22	21	15	2	6	3	19	16
90	21	16	65	21	14	7	16	7	17	3	14	12	27	15	26	1	8	3	20	16
100	25	15	72	64	15	9	17	7	20	8	14	11	29	9	25	1	6	3	20	17
110	23	15	84	19	17	6	19	4	23	13	17	11	34	7	23	13	7	3	20	16
120	24	16	88	26	18	6	20	4	24	0	18	2	37	6	23	1	7	3	21	13
130	25	19	91	86	20	17	21	17	28	26	20	12	42	25	28	1	7	3	21	21
140	23	16	94	85	20	6	23	4	28	0	17	13	38	6	15	1	7	3	22	13
150	25	24	97	61	22	20	25	21	31	28	17	2	43	39	25	1	8	3	22	19
160	26	16	99	87	23	6	25	4	31	0	15	15	47	7	29	1	9	3	22	14
170	26	15	99	99	23	6	25	4	33	2	17	13	48	7	29	1	10	3	23	13
180	25	18	99	90	24	17	26	14	34	6	19	6	48	21	24	1	7	3	22	19
190	26	14	99	96	26	7	28	4	36	0	20	11	49	7	27	1	8	3	24	14
200	28	13	99	96	25	6	27	4	35	0	24	10	51	7	16	2	8	3	23	13
218	46	25	100	48	37	14	29	16	69	17	25	13	49	30	63	9	8	3	22	18
236																				

Max value = maximum percentage of CPU utilization indicated for the Target Load sample period
Cur value = percentage of CPU utilization indicated at the sample time for the Target Load

Table 4.35.4-3 below shows the results from first test run on August 7, 1997. CPU utilization values were collected from Mode S Channel B until CPU 1 reached 100 percent. The client count in the scenario had advanced to 218 and the Mode S Channel B status went "red" causing a switch to Channel A. Note: The Mode S status had gone "yellow" during the 200 client level and 524 traps where listed in error log.

TABLE 4.35.4- 3. CHANNEL B CPU UTILIZATION FIRST RUN

	Mode S CPU																			
	0		**1**		**2**		**3**		**4**		**5**		**6**		**7**		**11**		**13**	
Target Load	M ax	C Ur	M ax	C ur	M ax	C Ur	M ax	C ur	M ax	C ur	M ax	C ur	M ax	C ur	M ax	C ur	M ax	C ur	M ax	C ur
50	20	13	31	16	10	6	10	4	11	0	16	0	15	5	15	1	7	3	17	4
60	20	18	36	33	12	10	12	10	15	7	16	1	19	16	11	1	4	4	19	13
70	20	15	44	19	12	7	12	5	14	11	16	16	20	10	12	8	5	3	19	14
80	20	16	53	44	13	7	14	4	15	7	16	7	24	5	15	1	8	3	19	16
90	22	18	66	66	14	14	16	15	18	15	18	6	28	26	12	1	5	5	20	18
100	26	17	71	64	16	11	17	9	19	1	17	9	29	14	12	1	8	3	21	18
110	24	18	83	76	17	13	19	11	25	6	17	14	34	16	12	1	6	3	21	16
120	26	19	92	88	19	16	20	14	26	11	18	15	37	21	12	1	7	3	21	19
130	25	24	92	74	20	19	21	19	27	21	19	10	41	31	12	1	7	3	22	20
140	26	15	97	97	21	11	22	9	28	7	20	12	40	10	14	1	7	3	22	18
150	27	16	98	88	23	8	24	5	31	2	20	11	44	6	15	1	9	3	22	15
160	29	18	99	89	23	15	25	12	33	21	17	12	44	17	13	1	7	3	21	19
170	28	19	98	92	24	16	25	14	34	0	18	9	48	21	15	2	9	3	22	19
180	28	16	99	92	25	15	26	12	33	25	20	8	48	18	14	1	9	3	22	17
190	30	22	99	91	26	17	30	15	41	2	21	10	48	21	12	1	8	3	22	20
200	31	23	100	90	26	22	28	19	36	10	22	8	52	29	19	1	8	3	23	20
218	41	27	100	65	37	21	29	21	72	26	40	11	47	41	63	7	8	4	22	19
236																				

Max value = maximum percentage of CPU utilization indicated for the Target Load sample period
Cur value = percentage of CPU utilization indicated at the sample time for the Target Load

Table 4.35.4-4 below shows the results from second test run on August 7, 1997. CPU utilization values were collected from Mode S Channel B until CPU 1 reached 100 percent. The client count in the scenario had advanced to 236 and the Mode S Channel B status went “red” causing a switch to Channel A.

TABLE 4.35.4- 4. CHANNEL B CPU UTILIZATION SECOND RUN

	Mode S CPU																			
	0		**1**		**2**		**3**		**4**		**5**		**6**		**7**		**11**		**13**	
Target Load	M ax	C Ur	M ax	C ur	M ax	C ur	M ax	C ur	M ax	C ur	M ax	C ur	M ax	C ur	M ax	C ur	M ax	C ur	M ax	C ur
50	20	16	31	18	10	6	9	4	8	0	18	1	13	5	14	1	6	3	18	15
60	20	19	36	20	11	8	11	8	10	3	17	17	17	11	12	8	5	3	18	14
70	22	14	40	29	12	6	12	4	13	0	17	5	20	5	13	1	6	3	20	11
80	23	16	51	38	13	6	14	4	17	0	17	7	24	5	14	1	6	3	20	15
90	22	15	58	45	14	6	16	4	17	6	17	7	27	5	13	2	7	3	20	14
100	25	16	66	59	16	10	17	8	19	0	17	8	27	12	14	1	8	3	21	17
110	25	20	87	85	18	14	22	14	25	9	18	14	37	20	13	1	7	3	21	20
120	25	17	89	81	19	14	21	13	26	8	17	13	39	18	13	2	7	3	21	18
130	26	14	92	68	20	6	21	4	27	13	22	12	38	6	14	1	7	3	22	14
140	27	15	95	86	21	6	24	4	29	0	18	12	39	6	13	1	7	3	21	14
150	28	22	96	96	24	21	25	21	35	27	18	11	44	35	15	2	7	6	23	19
160	29	24	97	94	24	22	26	20	32	28	17	9	45	36	14	1	7	6	22	21
170	29	17	99	99	24	11	26	9	41	23	18	10	47	11	15	2	8	3	22	18
180	28	23	98	97	25	22	26	21	35	4	19	7	47	34	13	1	9	6	22	19
190	30	15	99	95	26	6	30	4	36	7	20	11	47	7	14	1	9	3	22	15
200	32	29	99	93	26	26	27	26	38	22	22	11	49	45	18	1	7	3	23	21
218	34	15	99	97	26	8	27	5	35	17	28	15	48	6	16	1	10	3	22	17
236																				

Max value = maximum percentage of CPU utilization indicated for the Target Load sample period
Cur value = percentage of CPU utilization indicated at the sample time for the Target Load

4.5.5 Conclusions.

The shaded area of the previous four tables show the TIS client target load at which CPU utilization rises above 80 percent. To limit CPU utilization for all processors to 80 percent, a TIS client load of 100 must not be exceeded.

The “TIS Maximum Aircraft Supported” SAP should be set to 100 or less for field deployment.

4.6 DATA LINK BANDWITH DEMONSTRATION.

4.6.1 Test Objective/Criteria.

A very simple and limited test was conducted during the live flight tests to demonstrate that TIS does not significantly impact the data link channel capacity. Since GWS data density can be high, successful reception of GWS data (while continuing to supply TIS) would show that there is indeed ample excess capacity in the data link channel.

4.6.2 Test Description.

Lincoln Labs provided all the additional hardware, software and GWS data feed to support this demonstration. After the FAA test flight events were completed, while running the Mode S sensor with TIS active, one of the aircraft requested GWS.

4.6.3 Data Collection and Analysis Method.

Not Applicable. No data was collected, only observed on the GWS display.

4.6.4 Results/Discussion.

During the live flight tests the ADLP on the FAA aircraft was unable to connect to the GWS service. Therefore, no GWS data was received. However, GWS service was received (to a ground-based ADLP and TIS transponder) during system checkout and dry-runs.

4.6.5 Conclusions.

No conclusion could be reached since the formal demonstration failed.

However, in response to a request from the FAA Program Office, MITLL supplied two GA aircraft and air crew who flew modified versions of a subset of the TIS DT&E/OT&E Test plan flight plans. These flights were conducted simultaneous to, and totally independent of the FAA flight events. GWS service was received by one of the MITLL aircraft. See "Lincoln Laboratory Flight Test Results for Traffic Information Service (TIS) Operational Test And Evaluation" Report Number "42PM-Data-Link-0012" dated September 10, 1997, for details.

5. CONCLUSIONS.

Overall, the Traffic Information Service (TIS) data link services worked as expected and the ability of Mode Select (Mode S) to transfer data link communication messages performed properly. The TIS tracking algorithms performed flawlessly and according to specifications, with one minor exception. From the results, it is estimated that the overwhelming majority of TIS advisories were sent at the appropriate times. Some data in the advisories is inaccurate at times, but that is largely due to inaccuracies in the Mode S surveillance data.

Only three minor problems were found. All three were previously found during the TIS Operational Test and Evaluation (OT&E) for the Dulles Demonstration in 1995. The following paragraphs contain a summary of the problems.

5.1 SELF-ALERTS.

The self-alert is a relatively low frequency, nuisance problem. It should be eliminated (or drastically reduced) when the Terra modification is removed from the Mode S software.

5.2 INVALID ALTITUDES.

The invalid TIS altitude problem was another low frequency issue. It is not a TIS problem per se, but a Mode S surveillance problem that has minor impact on TIS accuracy. It should be corrected when there is a solution to the Mode S erroneous altitudes. This problem was previously identified, but no solution was available during the TIS testing.

5.3 TIS TRACKING ANOMALY.

The Intruder "crossover problem" is displayed in both scenario and live flight data. It was identified during the Dulles demo testing of TIS and still is an issue that poses the greatest liability. The crossover issue could cause a pilot, when viewing TIS, to potentially turn towards the intruder aircraft based on TIS information. Although this type of maneuvering should not occur very often during normal flights, it can and does happen. The TIS Program as a whole must ensure that this problem is corrected or documented in all pilot/user related documentation. The ACT-310 test group again emphasizes the problem and that it must not be overlooked.

In conclusion, the TIS software functions correctly and as good or better than the TIS Dulles Demonstration version for all measured parameters. The addition of the TIS data link services appear to have no adverse effect to the Mode S sensor operations. The Mode S data link capabilities function properly providing alerts and TIS service status messages in a timely manner.

6. RECOMMENDATIONS.

After completion of the formal Developmental Test and Evaluation/Operational Test and Evaluation (DT&E/OT&E) testing and detailed analysis and evaluation of Traffic Information Service (TIS), ACT-310 recommends that TIS be conditionally approved for national deployment contingent upon the following:

a. The Aeronautical Information Manual (AIM) and all other applicable user documentation must be revised to thoroughly document the self-alert problem.

b. The TIS tracker anomaly ("crossover problem") must be corrected in the TIS software or the AIM (and applicable user docs) must be revised to thoroughly document this limitation.

c. This version of TIS is only fielded in a terminal sensor configuration.

The ACT-310 test group also recommends that when fielded the "TIS Maximum Aircraft Supported" SAP be set to the value of 100 (or less) based on keeping the maximum CPU utilization for all processors under 80 percent, given the CPU utilization test results.

The following table (6-1) contains a summary of issues and recommendations suggested for incorporation prior to the national deployment of the TIS:

TABLE 6- 1. TIS ISSUES MATRIX

Seq #	Criticality	Description of Issues	Proposed Solution / Recommendation
1	Medium	Self-Alerts occur due to garbling of ATCRBS IDs, altitude amounts, and range readings. The Terra software algorithm identifies these reports as another target in close proximity, there by creating the Self-Alert.	Removal of the Terra software should eliminate these alerts, because the Mode S ID would be used for tracking. Until this occurs the AIM and all other applicable user (pilot) documentation **must** be revised to document this phenomenon. NOTE: The AIM is currently under revision to include this issue.
2	Medium	Invalid altitudes in excess of 50,000 feet were assigned to ATCRBS reports. These invalid altitudes affect the performance of the TIS tracker since TIS relies on the Mode S ATCRBS reports.	Mode S software should be fixed to correct this problem and TIS reliability would then be improved.
3	Medium	Intruder position displayed incorrectly, "crossover problem." For one particular maneuver, the intruder is displayed on the wrong side of the client.	Modify the tracker prediction algorithm to prevent this problem. Until this occurs the AIM and all other applicable user (pilot) documentation **must** be revised to document this phenomenon. NOTE: The AIM is currently under revision to include this issue.
4	Low	CPU Utilization	Based on a maximum allowable CPU utilization of 80 percent, a setting of 100 for the "TIS Maximum Aircraft Supported" SAP is recommended.
5	Low	TIS included in the EnRoute software build.	The ACT-310 test group recommends that TIS be extended to the Mode S EnRoute environment. This change would provide additional service to general aviation community.

CRITICALITY: Low - Minimum risk or impact that can be fixed in a routine manner
Medium - Significant risk but can be worked around on a temporary basis
High - Mission critical risk, must be fixed prior to deployment

7. ACRONYMS AND ABBREVATIONS.

ADLP	Airborne Data Link Processor
AIM	Aeronautical Information Manual
AIN	Application Identification Number
ARIES	Aircraft Reply and Interference Environmental Simulator
ASR-9	Airport Surveillance Radar Model 9
AT	Air Traffic
ATC	Air Traffic Control
ATCBI-5	Air Traffic Control Beacon Interrogator Model 5
ATCRBS	Air Traffic Control Radar Beacon System
CID	Communications Interface Driver
COI	Critical Operational Issues
CPME	Calibration Precision Monitoring Equipment
CPU	Central Processor Unit
DI	Dimensions International, Inc.
DT&E	Developmental Test and Evaluation
DR	Data Reduction Program
GICB	Ground-initiated Comm B transponder register
GWS	Graphical Weather Service
IBI	Interim Beacon Interrogator
ID	Identification
LMT	Local Maintenance Terminal
ISLS	Improved side lobe suppression.
MITLL	Massachusetts Institute of Technology Lincoln Laboratory
Mode S	Mode Select

MSL	Mean Sea Level
MSP	Mode S-Specific Protocol
NAS	National Airspace System
OT&E	Operational Test and Evaluation
PC	Personal Computer
Pd	Probability of Detection
Pfa	Probability of False Alarm
RBAT	Radar Beacon Analysis Tool
RF	Radio Frequency
RIT	Radar Intelligence Tool
RT	Remote Terminal
RTADS	Real-Time Aircraft Display System
RU	Mode S sensor Range Unit
SAP	Site Adaptation Parameter
SCIP	Surveillance and Communication Interface Processor
SCM	System Configuration Managed
SLS	Side Lobe Suppression.
SPR	System Problem Report
STC	Sensitivity Time Constant
T&E	Test and Evaluation
TCAS	Traffic Alert and Collision Avoidance System
TIS	Traffic Information Service
TSCR	TIS Connection Request
TSDR	TIS Disconnection Request
TU	Mode S sensor Time Unit
TVRTM	Test Verification Requirements Traceability Matrix

APPENDIX A
SCENARIO DESCRIPTIONS

SCENARIO DESCRIPTIONS

Scenario Identifier	Parameters of Scenario
TISCRCL4	This scenario consists of one TIS client and one intruder. The aircraft fly a Crossing pattern, while Climbing, with the client located 45 miles from sensor flying North at start of the scenario. The intruder flies east crossing the client's flight path. The client flies at a constant speed of 120 knots and the intruder flies at a constant speed of 150 knots.
TISCRCL8	This scenario consists of one TIS client and one intruder. The aircraft fly a Crossing pattern, while Climbing, with the client located 8 miles from sensor flying North at start of the scenario. The intruder flies east crossing the client's flight path. The client flies at a constant speed of 120 knots and the intruder flies at a constant speed of 150 knots.
TISCRDS4	This scenario consists of one TIS client and one intruder. The aircraft fly a Crossing pattern, while Descending, with the client starting 45 miles from sensor flying North at start of scenario. The intruder flies east crossing the client's flight path. The client flies at a constant speed of 120 knots and the intruder flies at a constant speed of 150 knots.
TISCRDS8	This scenario consists of one TIS client and one intruder. The aircraft fly a Crossing pattern, while Descending, with the client starting 8 miles from sensor flying North at start of scenario. The intruder flies east crossing the client's flight path. The client flies at a constant speed of 120 knots and the intruder flies at a constant speed of 150 knots.
TISCRLL4	This scenario consists of one TIS client and one intruder. The aircraft fly a Crossing pattern, in Level flight, with the client starting 45 miles from sensor flying North at start of scenario. The intruder flies east crossing the client's flight path. The client flies at a constant speed of 120 knots and the intruder flies at a constant speed of 150 knots.
TISCRLL8	This scenario consists of one TIS client and one intruder. The aircraft fly a Crossing pattern, in Level flight, with the client starting 8 miles from sensor flying North at start of scenario. The intruder flies east crossing the client's flight path. The client flies at a constant speed of 120 knots and the intruder flies at a constant speed of 150 knots.
TISHCSP4	This scenario consists of one TIS client and two intruders. The aircraft primary (FAA001 and FAA002) fly Head-On, while Climbing, with the client (FAA001) starting 45 miles from sensor flying North. A second intruder, ATCRBS only, was added and this intruder crosses the client's flight path after the primary intruder has passed the client. The beacon responses will be inhibited from all IDs for a few scans to cause track coasts and track drops. The client flies at a constant speed of 120 knots and the intruders fly at a constant speed of 150 knots.

Scenario Identifier	Parameters of Scenario
TISHCSP8	This scenario consists of one TIS client and one intruder. The aircraft fly Head-On, while Climbing, with the client starting 8 miles from sensor at start of scenario and the rate of altitude change will be at 400 feet per minute. The client flies at a constant speed of 120 knots and the intruder flies at a constant speed of 150 knots.
TISHCSPX	This scenario consists of one TIS client and two intruders. The primary (FAA001 and FAA002) aircraft fly Head-On, while Climbing, with the client (FAA001) starting 45 miles from sensor at start of scenario. A second intruder, ATCRBS only, was added and this intruder crosses the client's flight path after the primary intruder has passed the client. The altitude responses will be inhibited from all IDs for up to 10 scans to cause track coasts and track drops. The client flies at a constant speed of 120 knots and the intruders fly at a constant speed of 150 knots.
TISHDSP8	This scenario consists of one TIS client and one intruder. The aircraft fly Head-On, while Descending, with the client starting 8 miles from sensor at start of scenario and the rate of altitude change will be at 400 feet per minute. The client flies at a constant speed of 120 knots and the intruder flies at a constant speed of 150 knots.
TISHLSP4	This scenario consists of one TIS client and one intruder. The aircraft fly Head-On, in Level flight, with the client starting 45 miles from sensor. The intruder will fly South at 150 knots and increase speed to 280 knots during scenario. The client flies at a constant 120 knots.
TISHLSP8	This scenario consists of one TIS client and one intruder. The aircraft fly Head-On, in Level flight, with the client starting 8 miles from sensor. The client will fly North at 120 knots and increase speed to 280 knots during scenario. The intruder flies at a constant 150 knots.
TISHOCL4	This scenario consists of one TIS client and one intruder. The aircraft fly Head-On, while Climbing, with the client starting 45 miles from sensor flying North at start of scenario. The intruder flies South until it has passed the client by 10 miles. The client flies at a constant speed of 120 knots and the intruder flies at a constant speed of 150 knots.
TISHOCL8	This scenario consists of one TIS client and one intruder. The aircraft fly Head-On, while Climbing, with the client starting 8 miles from sensor flying North at start of scenario. The intruder flies South until it has passed the client by 10 miles. The client flies at a constant speed of 120 knots and the intruder flies at a constant speed of 150 knots.
NONHOCL8	Same event as TISHOCL8, but there are no duplicate ATCRBS targets for Terra mode. This is a Non-Terra version of scenario TISHOCL8.
TISHODS5	This scenario consists of one TIS client and one intruder. The aircraft fly Head-On, while Descending, with the client starting 45 miles from sensor flying North at start of scenario. The intruder flies South until it has passed the client by 10 miles. The client flies at a constant speed of 120 knots and the intruder flies at a constant speed of 150 knots.

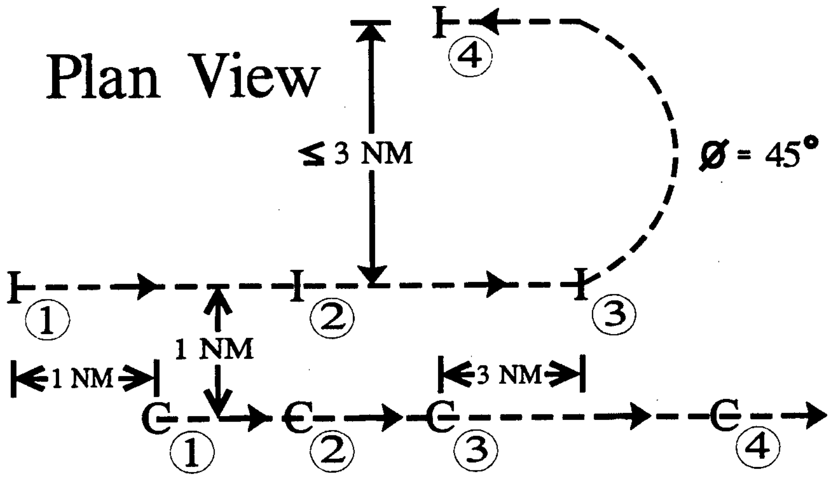
Scenario Identifier	Parameters of Scenario
TISHODS8	This scenario consists of one TIS client and three intruders. The primary aircraft (FAA001 and FAA002) fly Head-On, while Descending, with the client (FAA001) starting 8 miles from sensor flying North at start of scenario. The client (FAA001) flies at a constant speed of 120 knots and the intruder (FAA002) flies at a constant speed of 150 knots. The intruder (FAA002) flies South until it has passed the client by 10 miles. Two additional intruders flying at 100 knots were added later in the scenario to generate alerts with the client as the intruders pass. These intruders are only active for 1 minute and are then dropped.
TISHOLL4	This scenario consists of one TIS client and one intruder. The aircraft fly Head-On, in Level flight, with the client starting 45 miles from sensor flying North at start of scenario. The intruder flies South until it has passed the client by 10 miles. The client flies at a constant speed of 120 knots and the intruder flies at a constant speed of 150 knots.
TISHOLL8	This scenario consists of one TIS client and one intruder. The aircraft fly Head-On, in Level flight, with the client starting 8 miles from sensor flying North at start of scenario. The intruder flies South until it has passed the client by 10 miles. The client flies at a constant speed of 120 knots and the intruder flies at a constant speed of 150 knots.
TISOTCL4	This scenario consists of one TIS client and one intruder. The aircraft fly an Overtaking route, while Climbing, with the client starting 45 miles from sensor flying North at start of scenario. The intruder will overtake and pass the client. The client flies at a constant speed of 120 knots and the intruder flies at a constant speed of 150 knots.
TISOTCL8	This scenario consists of one TIS client and one intruder. The aircraft fly an Overtaking route, while Climbing, with the client starting 8 miles from sensor flying North at start of scenario. The intruder will overtake and pass the client. The client flies at a constant speed of 120 knots and the intruder flies at a constant speed of 150 knots.
TISOTDS4	This scenario consists of one TIS client and one intruder. The aircraft fly an Overtaking, while Descending, with the client starting 45 miles from sensor flying North at start of scenario. The intruder will overtake and pass the client. The client flies at a constant speed of 120 knots and the intruder flies at a constant speed of 150 knots.
TISOTDS8	This scenario consists of one TIS client and one intruder. The aircraft fly an Overtaking route, while Descending, with the client starting 8 miles from sensor flying North at start of scenario. The intruder will overtake and pass the client. The client flies at a constant speed of 120 knots and the intruder flies at a constant speed of 150 knots.

Scenario Identifier	Parameters of Scenario
TISOTLL4	This scenario consists of one TIS client and one intruder. The aircraft fly an Overtaking route, in Level flight, with the client starting 45 miles from sensor flying North at start of scenario. The intruder will overtake and pass the client. The client flies at a constant speed of 120 knots and the intruder flies at a constant speed of 150 knots.
TISOTLL8	This scenario consists of one TIS client and one intruder. The aircraft fly an Overtaking route, in Level flight, with the client starting 8 miles from sensor flying North at start of scenario. The intruder will overtake and pass the client. The client flies at a constant speed of 120 knots and the intruder flies at a constant speed of 150 knots.
TISXOVRB	This scenario consists of one TIS client flying North on a Level flight, 8 miles from sensor at start of scenario. A single intruder aircraft will approach from 4 miles on an angle to within 1/4 mile, then turn sharply and fly parallel to the client. The client flies at a constant speed of 135 knots and the intruder flies at a speed of 141 knots until the turn, then increases speed to 218 knots.
TISXOVRS	Same event as TISOVRB, but there are no duplicate ATCRBS targets for Terra mode. This is a Non-Terra version of scenario TISXOVRB.
TIS200	This scenario consists of 150 ATCRBS targets and 50 TIS client aircraft. The 50 TIS clients issue requests for service during the scenario. The client aircraft fly at speeds as low as 30 knots up to 160 knots. The ATCRBS intruder aircraft fly at speeds from 35 knots up to 160 knots. All the aircraft are located in a dense pattern of approximately 125°.
NON200	Same event as TIS200, but there are no duplicate ATCRBS targets for Terra mode. This is a Non-Terra version of scenario TIS200.
TIS4411S	This scenario consists of six different targets requesting TIS service. The first target starts within coverage and flies outbound beyond 75 nmi range. The second target starts outside the 75 nmi range and flies inbound into coverage. The third target will fly through the zenith cone. The forth target starts in the center of the zenith cone and flies outbound leaving the zenith cone. The fifth target does not request TIS service until the scenario has been running for awhile. The sixth target starts on the y-axis 55 nmi to the east and flies north descending to –100 feet altitude and then returning to 4000 feet. FAA001 and FA002 fly at 420 knots; FAA003 flies at 480 knots; FAA004 and FAA005 fly at 240 knots; and FAA006 flies at 120 knots.
TIS4421	This scenario consists of one TIS client flying outbound on a radial situated between two intruder aircraft flying one degree to the left and right. The client and intruders fly at a constant 60 knots.

Scenario Identifier	Parameters of Scenario
TIS4422	This scenario consists of 3 groups of 5 targets, each containing one TIS client with four intruders. The clients all fly outbound, as well as the intruders. The groups are different as far as intruder altitude and heading in relation to the client. Each group will cause a different sequence of proximate and traffic advisories. The client aircraft fly at a constant speed of 60 knots and the intruders fly at constant speeds of 62 and 63 knots.
TIS4423	This scenario consists of one TIS client and eight intruders. Four of the intruders will generate proximate advisories and four of the intruders will generate traffic advisories. The client aircraft flies at a constant speed of 60 knots and the intruders fly at constant speeds of 61, 62, and 63 knots.
NON4423	Same event as TIS4423, but there are no duplicate ATCRBS targets for Terra mode. This is a Non-Terra version of scenario TIS4423.
TIS4424	This scenario consists of 1 TIS client and 12 intruders. The 12 intruders will fly so as to cause 12 advisories to be generated at 1 time. The client aircraft flies at a constant speed of 60 knots and the intruders fly at constant speeds of 60, 62, and 120 knots.
NON4424	Same event as TIS4424, but there are no duplicate ATCRBS targets for Terra mode. This is a Non-Terra version of scenario TIS4424.
UNBRAMP	This scenario starts with 50 TIS client aircraft and then increases the number of TIS client's by 10 every 2 minutes until it reaches 200 TIS clients. The targets are spread out over the entire coverage area and fly at range of speeds from 50 knots to as high as 630 knots.

APPENDIX B
FLIGHT EVENT DESCRIPTIONS

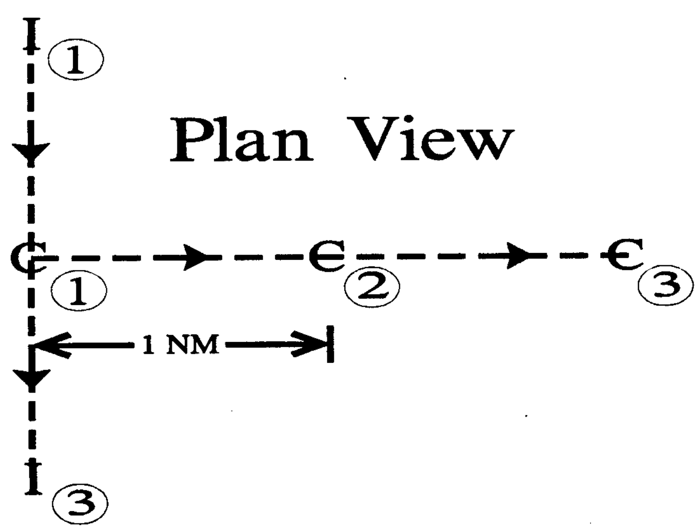
Event A



Client = 6600 feet, 170 KIAS, N 39
Intruder = 6200 feet, 220 KIAS, N 49

A. During this event, the Intruder (I) aircraft over took the Client (C) aircraft flying at 400 feet below and parallel to the Client, until the Intruder was at least 3 nmi ahead of the Client. The Intruder then made a 180° turn to the left closing to a range of approximately 3 nmi and flew in the opposite direction of the Client on a parallel path until it had passed the Client.

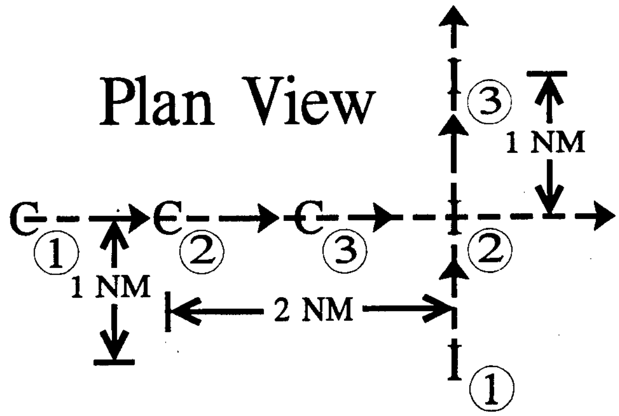
Event B



Client = 6600 feet, 180 KGS, N 39
Intruder = 6300 feet, 180 KGS, N 49

B. During this event, the Intruder (I) aircraft passed perpendicular and behind the Client (C) aircraft at approximately 1 nmi and 300 feet below the Client.

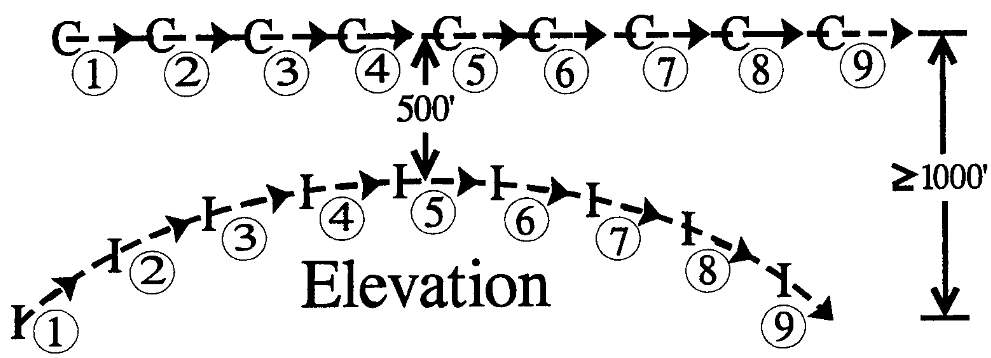
Event C



Client =   6900 feet, 180 KGS, N 39
Intruder = 6300 feet, 180 KGS, N 49

C. During this event, the Intruder (I) crossed ahead of the Client (C) at a range of approximately 2 nmi and 600 feet below the Client.

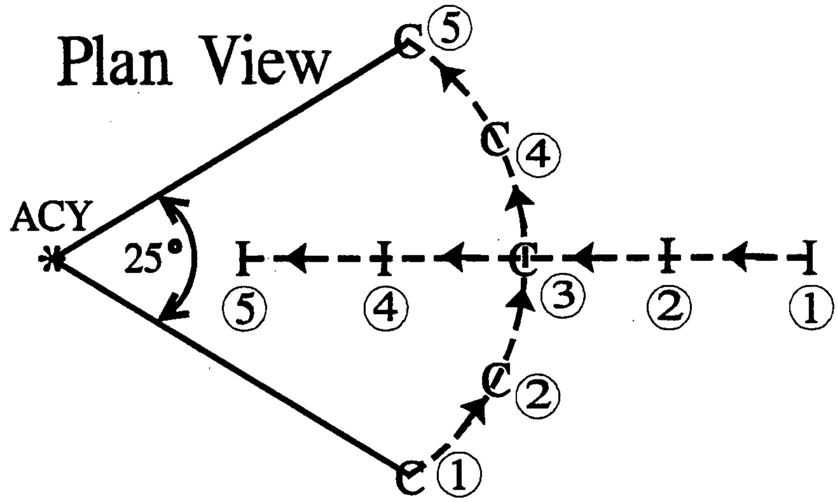
Event D



Client =   6600 feet, 180 KIAS, N 39
Intruder = 5600 feet, 180 KIAS, N 49

D. During this event, the Intruder (I) flew on the same course as the Client (C), starting at 1000 feet below the Client. The Intruder then ascended at 200 feet per minute to within 500 feet of the Client. The Intruder then continued on the same course as Client descending at a rate of 700 feet per minute to an altitude on 1000 feet below Client.

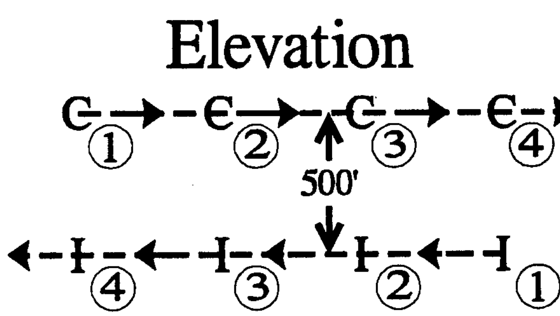
Event E



Client = 6900 feet, 180 KGS, N 39
Intruder = 6300 feet, 180 KGS, N 49

E. During this event, the Client (C) flew on a 25° arc at a range of 25 nmi from the sensor (ACY). The Intruder (I) then started 30 nmi from the sensor (ACY) and flew perpendicular through the arc at an altitude of 600 feet below the Client at the crossing point.

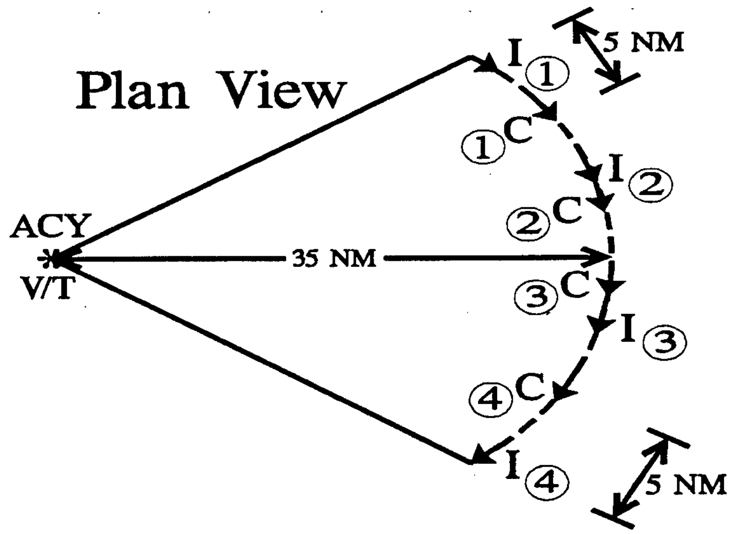
Event F



Client = 6600 feet, 170 KGS, N 39
Intruder = 6200 feet, 170 KGS, N 49

F. During this event, the Client (C) and the Intruder (I) flew head-on (opposite directions) at an altitude difference of 500 feet on the same radial starting at 5 nmi apart and closed passing over each other. The Intruder was at an altitude 400 feet below the Client when they passed under.

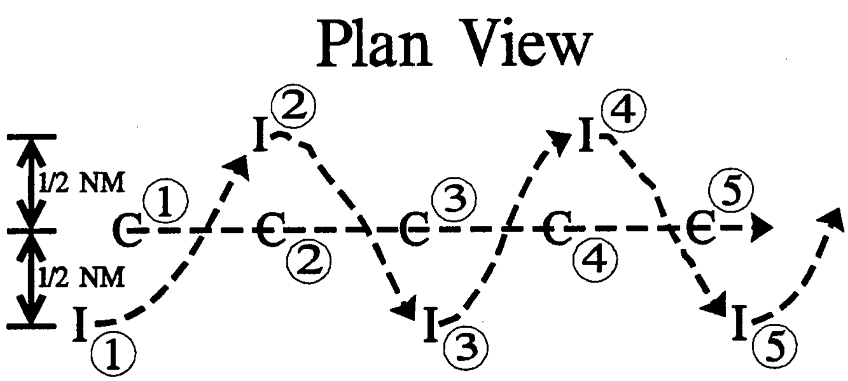
Event G



Client = 6300 feet, 150 KIAS, N 39
Intruder = 6900 feet, 220 KIAS, N 49

G. This event was planned for the Client (C) to fly clockwise on an arc at a range of 35 nmi from the sensor (ACY). The Intruder (I) started 5 nmi behind the Client flying on the same arc, but before overtaking the Client the aircraft had to reverse direction due to airspace limitations. The Client became the Intruder and then continued until it overtook the Client (old Intruder). The Intruder flew at an altitude 600 feet above the Client until it was 5 nmi ahead of the Client.

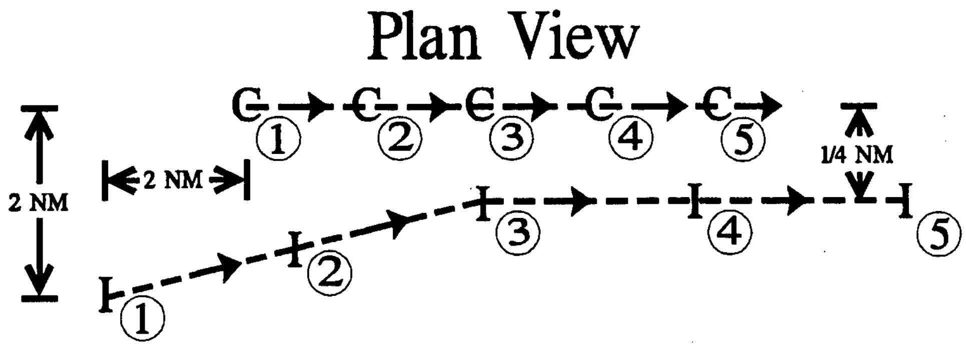
Event H



Client = 6600 feet, 160 KIAS, N 39
Intruder = 6300 feet, 160+ KIAS, N 49

H. For this event, the Client (C) flew in a straight line. The Intruder (I) flew an S pattern crossing the Client's flight path by approximately 1/2 nmi before turning. The Intruder crossed over four times as they overtook and passed the Client at an altitude 300 feet below the Client.

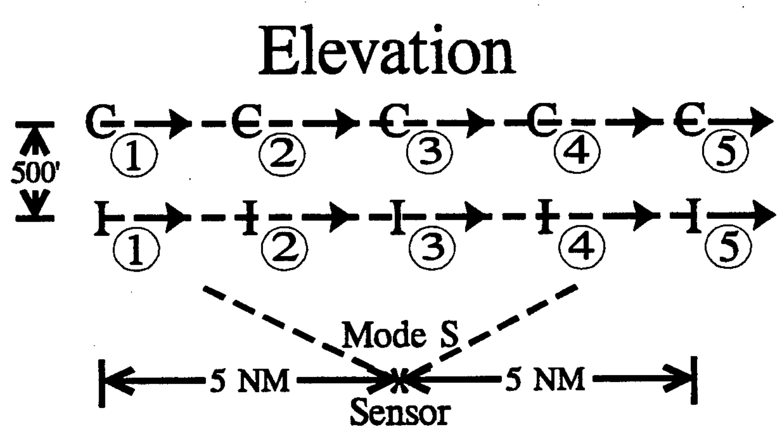
Event I



Client = 6600 feet, 150 KIAS, N 39
Intruder = 6300 feet, 220 KIAS, N 49

I. During this event, the Intruder (I) started from a range of 2 nmi behind and 2 nmi off the right wing of the Client (C). The Intruder then flew toward the Client to a range of approximately 1/2 nmi and then turned right to a path parallel to the Client. The Intruder then flew ahead of the Client for one minute. The Intruder flew at 300 feet below Client.
NOTE: This event was conducted outside 30 nmi of the sensor and within 30 nmi of the sensor.

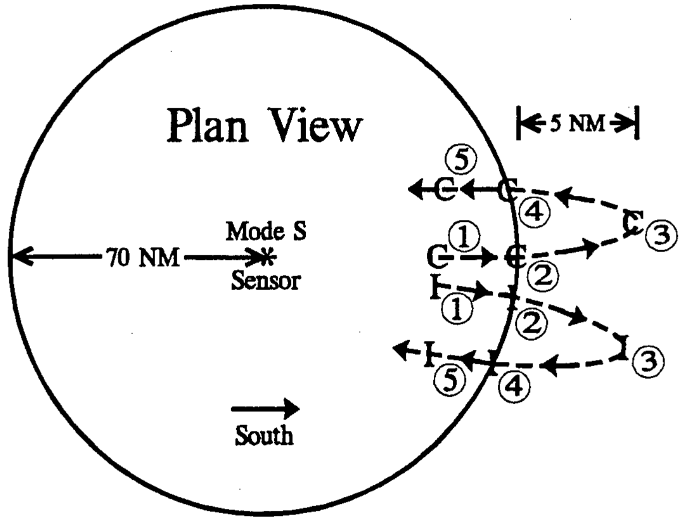
Event J



Client = 6600 feet and 6600 feet, 170 KIAS, N 39
Intruder = 3700 feet and 6200 feet, 170 KIAS, N 49

J. During this event, the Client (C) and the Intruder (I) aircraft flew through the zenith cone at the ACY Mode S sensor (Lat 39° 27 min 5.54 sec, Long 74° 34 min 14.21 min) to a range of 5 nmi past ACY. Two passes through the zenith cone were conducted. In the first pass, the aircraft had an altitude difference of 2900 feet and during the second pass the altitude difference was 500 feet. The altitude differences allowed the test group to observe the affect of the zenith cone angle. The Intruder was within 1 nmi of the Client during both passes.

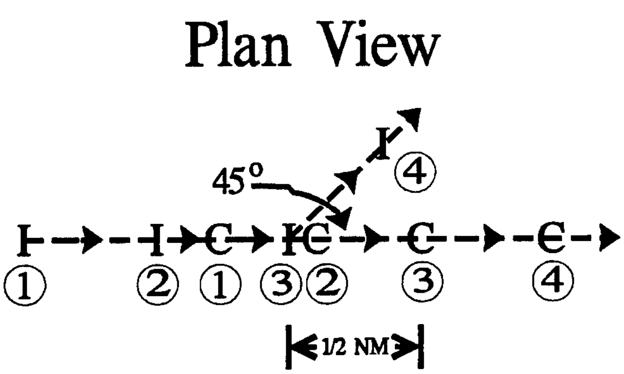
Event K



Client = 6600 feet, Aprox. 170 KIAS, N 39
Intruder = 6300 feet, Aprox. 170 KIAS, N 49

K. During this flight maneuver, the aircraft went beyond the edge of sensor coverage. When this occurred the Client (C) and the Intruder (I) continued on the flight paths that took them approximately 75 nmi from sensor (ACY). The aircraft then made turns that returned them back into ACY coverage.

Event L



Client = 6600 feet, 160 KIAS, N 39
Intruder = 6200 feet, 220 KIAS, N 49

L. During this event, the Intruder (I) and Client (C) flew on the same radial with the Intruder starting 5 nmi to the rear of the Client. The Intruder closed to 1/2 nmi of the Client, then the Intruder turned on a 45° course to the left of the Client and continued for 2 nmi. The Intruder flew at 400 feet below the Client's altitude.

APPENDIX C
PRODUCT TEST VERIFICATION REQUIREMENTS TRACEABILITY MATRIX (TVRTM)

TEST VERIFICATION REQUIREMENTS TRACEABILITY MATRIX

Matrix Definitions:

Test Phases: DT&E (Development Test & Evaluation) OT&E (Operational Test & Evaluation)

Verification Method: AT (Analysis Tool)
CI (Code Inspection)
FT (Flight Test)
NT (Non-testable)
SD (Scenario/Data Analysis)

Test Scenario or Live Flight: Scenario Identifier, Flight Number or N/A (Not Applicable)

Req. #	Spec Para	Requirement Text	Test Phase	Verification Method	Test Report Verification Paragraph	Test Scenario or Live Flight
1.0	3.1	There shall be two TIS processing tasks: the tracker, and the alert generator.	DT&E	CI	4.1	N/A
2.0	3.1	The tracker task shall receive inputs from the sensor surveillance functions and maintain a local TIS track file that is shared between the TIS tracker task and alert generation task.	OT&E	SD	4.2.13	TISHOLL8
3.0	3.1	TIS tracks shall be updated at the time that surveillance inputs appear.	OT&E	SD	4.2.13	TISHOLL8
4.0	3.1	Aircraft which are requesting TIS service shall have their TIS track references placed on an azimuth sector list that forms the shared interface between the tracker task and the alert generation task.	OT&E	SD	4.2.13	TISHOLL8
5.0	3.1	The alert generation task, (executing concurrently with the TIS tracker task) shall access the sector list running at least 90 degrees (8 sectors) but not more than 270 degrees (24 sectors) behind the surveillance processing.	OT&E	SD	4.2.13	TISHOLL8
6.0	3.1	Any TIS messages generated in the alert generation task shall be fed to the sensor data link functions.	OT&E	SD	4.2.13	TISHOLL8
7.0	3.1	An input from the sensor data link functions shall provide the source of TIS downlink request messages which enable or disable TIS service to a particular aircraft.	OT&E	FT	4.3.1	Live Flt #1

Req. #	Spec Para	Requirement Text	Test Phase	Verification Method	Test Report Verification Paragraph	Test Scenario or Live Flight
8.0	3.1.1	TIS shall receive data from the sensor in the following units: range in range units (RU), angles in azimuth units (AU), altitude in flight levels (100 feet), and times in time units (TU).	OT&E	SD	4.2.3	TISCRCL8
9.0	3.1.1	The TIS implementation shall compute distances in RU, altitude in feet and times in TU.	OT&E	SD	4.2.3	TISCRCL8
10.0	3.1.1	TIS horizontal velocities shall be computed in integer RU per hour, while TIS vertical velocities shall be computed in integer feet per hour.	OT&E	SD	4.2.3	TISCRCL8
11.0	3.1.1	Angles shall be measured according to ATC conventions -- clockwise from North.	OT&E	SD	4.2.3	TISCRCL8
12.0	3.2	All of the major data structures shall be local to the TIS processing and shall be volatile -- they shall be regenerated upon re-initialization of the TIS processing.	DT&E	CI	4.1	N/A
13.0	3.2.1	TIS shall maintain a separate, parallel track file data structure from the sensor surveillance.	OT&E	SD	4.2.19	TISOTLL8
14.0	3.2.1	The TIS Track File shall be configured as an array with entries indexed for each possible track number in surveillance.	DT&E	CI	4.1	N/A
15.0	3.2.1	Each track file entry shall contain the items described below: General Data Slant Range of latest update — Range Azimuth of latest update — Azimuth Time of latest update — time ATCRBS code — code Mode S ID (if Mode S) — ms_code Track Type (ATCRBS or Mode S) — track_type correlation maturity flag — corr_maturity Aircraft Transponder capability — capability Track number — trackno Ground Speed — speed Speed flag (0 if speed < 250 knots, else 1) — speed_flag Horizontal Tracker Data Internal x-y position — XPI,YPI Internal x-y velocity — XDI,YDI Internal firmness — FIRMI External x-y position — XPE,YPE External x-y velocity — XDE,YDE External firmness — FIRME	DT&E	CI	4.1	N/A

Req. #	Spec Para	Requirement Text	Test Phase	Verification Method	Test Report Verification Paragraph	Test Scenario or Live Flight
		Time of last update last_upd_time Horizontal State track_state Turn State turn_state x-y sort bin indices xbin,ybin sort bin link sort_link sector number sector sector list link sector_link Vertical Tracker Data Vertical position ZP Vertical velocity ZD Time of last altitude update alt_upd_time Altitude State alt_state Vertical position used in last rate update ZPR Smoothed altitude residual resid Extent of altitude trend alt_trend_time Time of last altitude transition alt_trans_time Time since altitude rate was estimated alt_rate_time Uncertainty in altitude transition time alt_guess_time Altitude transition since transition time alt_trans_diff Sign of last altitude transition alt_direction Track has Mode C altitude flag have_alt_flag Message Generation Data TIS requested flag tis_req_flag New TIS request flag new_tis_flag In TIS coverage flag in_cover_flag In TIS zenith cone flag in_zenith_cone_flag Send goodbye flag send_goodbye_flag No report received flag no_report_flag Message sent flag (traffic / keep-alive) msg_sent_flag Time of last TIS uplink message last_uplink_time Last TIS uplink message number last_msg_no				
16.0	3.2.2	The TIS coverage map shall parallel the sensor surveillance coverage map.	DT&E	CI	4.1	N/A
17.0	3.2.2	The TIS coverage map shall have entries indexed by range and azimuth.	DT&E	CI	4.1	N/A

Req. #	Spec Para	Requirement Text	Test Phase	Verification Method	Test Report Verification Paragraph	Test Scenario or Live Flight
18.0	3.2.2	Each TIS coverage map entry shall have two elements: in-coverage flag (TRUE if cell in TIS coverage, FALSE otherwise) TIS coverage altitude floor (lowest altitude for TIS coverage)	DT&E	CI	4.1	N/A
19.0	3.2.2	The TIS Coverage Map data structure shall be initialized during TIS initialization processing from the contents of the sensor surveillance coverage map.	DT&E	CI	4.1	N/A
20.0	3.2.2	The TIS coverage map shall be accessed by the Mode S processing of the TIS tracker task to determine whether a TIS-requesting aircraft's track should be placed onto the sector lists, and whether a goodbye uplink message is required.	OT&E	SD	4.2.25	TIS4411S
21.0	3.2.3	Each sensor performance monitor CPME position shall be converted to x-y units for the TIS performance monitor functions.	DT&E	CI	4.1	N/A
22.0	3.2.3	Each CPME position data structure shall contain the following fields in addition to the sensor CPME values which include CPME range, azimuth, altitude, ATCRBS code, and Mode S identifier: Xpos (CPME X coordinate) Ypos (CPME Y coordinate) Xerr (tolerance in the X-direction) Yerr (tolerance in the Y-direction) Verr (tolerance in velocity)	DT&E	CI	4.1	N/A
23.0	3.2.4	Two sets of track sort lists shall be maintained in the TIS tracker task to assist in the coarse screening process.	DT&E	CI	4.1	N/A
24.0	3.2.4	One set of track sort lists shall be maintained for "slow" aircraft (aircraft whose ground speed is less than 250 knots).	DT&E	CI	4.1	N/A
25.0	3.2.4	A second set of track sort lists shall be maintained for "fast" aircraft (aircraft whose ground speed is greater than or equal to 250 knots).	DT&E	CI	4.1	N/A
26.0	3.2.4	Each sort list shall be a singly-linked structure whose elements contain references to TIS track file entries.	DT&E	CI	4.1	N/A
27.0	3.2.4	The headers of each set of sort lists shall be contained in a doubly-dimensioned square array whose elements shall be indexed as a function of the x-y position of the desired track.	DT&E	CI	4.1	N/A

Req. #	Spec Para	Requirement Text	Test Phase	Verification Method	Test Report Verification Paragraph	Test Scenario or Live Flight
28.0	3.2.4	Tracks of a desired speed range located in a geographic position shall be identified through the following steps: 1) choose the appropriate sort list header array based on speed 2) index the appropriate sort list header based on x-y position 3) search the linked list for tracks meeting the requirements	DT&E	CI	4.1	N/A
29.0	3.2.4	The size of the x-y regions for each "slow" sort list shall be the distance an aircraft would fly at 250 knots over the TIS look-ahead time of 120 seconds.	DT&E	CI	4.1	N/A
30.0	3.2.4	The size of the x-y regions for each "fast" sort list shall be based on a 750 knot ground speed.	DT&E	CI	4.1	N/A
31.0	3.2.5	A set of 32 singly-linked sector lists shall be used as the interface between the TIS Tracking task and the TIS Alert Generation task.	DT&E	CI	4.1	N/A
32.0	3.2.5	Each active TIS track (a track for an aircraft currently receiving TIS service from the sensor) shall be attached to one of the sector lists according to its current azimuth.	OT&E	SD	4.2.19	TISOTLL8
33.0	3.2.5	The TIS Tracker task shall handle the appropriate linking of tracks on the sector lists.	OT&E	SD	4.2.19	TISOTLL8
34.0	3.3	The following set of site-adaptable parameters (SAPs) shall control the operation of TIS processing: TIS Enable/Disable Flag TIS Maximum Aircraft Supported TIS Zenith Cone Angle TIS Magnetic Deviation Angle	OT&E	SD	4.2.25	TIS4411S
35.0	3.3	Local copies of the SAPs shall be made during system initialization or restart.	DT&E	CI	4.1	N/A
36.0	3.3.1	The TIS Enable/Disable Flag SAP shall enable or disable TIS processing.	OT&E	SD	4.2.25	TIS4411S
37.0	3.3.1	When TIS is disabled, a TIS-equipped sensor shall operate such that no TIS processing is being performed.	OT&E	SD	4.2.25	TIS4411S
38.0	3.3.1	When TIS is disabled, although the TIS software shall remain in memory, the software shall not be executed.	OT&E	SD	4.2.25	TIS4411S
39.0	3.3.2	The TIS Maximum Aircraft Supported SAP shall control the number of aircraft requesting TIS service that may be granted service.	OT&E	SD	4.2.30	UNBRAMP

Req. #	Spec Para	Requirement Text	Test Phase	Verification Method	Test Report Verification Paragraph	Test Scenario or Live Flight
40.0	3.3.2	The maximum legal value for the TIS Maximum Aircraft Supported SAP shall be the maximum number of Mode S aircraft tracks allowed by the sensor.	OT&E	SD	4.2.30	UNBRAMP
41.0	3.3.3	TIS shall maintain a separate zenith cone angle SAP from the one used in sensor surveillance.	OT&E	SD	4.2.25	TIS4411S
42.0	3.3.3	The TIS Zenith Cone Angle SAP shall be used in the initialization of the zenith cone table.	OT&E	SD	4.2.25	TIS4411S
43.0	3.3.4	The TIS Magnetic Deviation Angle SAP shall designate the value of magnetic North correction required at the sensor site.	OT&E	SD	4.2.25	TIS4411S
44.0	3.3.4	TIS message formation shall use the TIS Magnetic Deviation Angle SAP value to uplink the magnetic North-corrected own-aircraft ground-track field.	OT&E	SD	4.2.19	TISOTLL8
45.0	3.3.4	The only use that the sensor makes of magnetic correction shall be for the calculation of own-aircraft ground_track, as all other sensor angles shall be measured with respect to true North.	DT&E	CI	4.1	N/A
46.0	3.4	The various TIS data structures and local copies of the SAPs shall be initialized in the TIS processing at sensor startup and during a channel switch.	DT&E	CI	4.1	N/A
47.0	3.4	At initialization, the flag controlling the sensor-TIS surveillance interface shall be set FALSE.	DT&E	CI	4.1	N/A
48.0	3.4	A check for the channel switch condition shall be performed once per scan at the northmark.	DT&E	CI	4.1	N/A
49.0	3.4.1	All entries in the TIS track file shall be initialized in the TIS tracker task upon sensor startup, sensor channel switch, and recovery.	DT&E	CI	4.1	N/A
50.0	3.4.1	All the TIS track position and velocity values shall be initialized to zero and flag values shall be initialized to FALSE.	DT&E	CI	4.1	N/A
51.0	3.4.1	Other TIS track element initialization values shall be as follows: track_state = FIRST turn_state = NOTURN alt_state = INIT last_msg_no = 1	DT&E	CI	4.1	N/A
52.0	3.4.2	The TIS coverage map shall be initialized from the contents of the sensor surveillance coverage map data structure.	DT&E	CI	4.1	N/A

Req. #	Spec Para	Requirement Text	Test Phase	Verification Method	Test Report Verification Paragraph	Test Scenario or Live Flight
53.0	3.4.2	For each range-azimuth cell in the TIS coverage map, a search shall be performed looking at neighboring cells in the sensor surveillance coverage map up to 5 nautical miles (converting from x-y to range-azimuth coordinates) from the center of the TIS coverage map cell being processed.	DT&E	CI	4.1	N/A
54.0	3.4.2	If any of the surveillance coverage map cells being searched (1) are not in surveillance coverage, or (2) have an outer range which is greater than the site-adaptable radar range mask value for any entry in the radar range mask array which overlaps the cell, or (3) are not indicated as PRIMARY for the sensor's coverage, then the cell being processed of the TIS coverage map shall be set to indicate "no TIS coverage" and its altitude floor shall be defaulted to zero.	DT&E	CI	4.1	N/A
55.0	3.4.2	If the TIS coverage map cell being processed is not to be set to "no TIS coverage", the TIS coverage map altitude floor shall be set to the highest altitude found in any of the sensor surveillance coverage map cells searched for the TIS coverage map cell being processed.	DT&E	CI	4.1	N/A
56.0	3.4.2	Whenever the altitude floor of the sensor surveillance coverage map cell that corresponds to a TIS coverage map cell is set to the default value, then the TIS processing shall use an alternate method to generate a "reasonable" altitude floor for that TIS coverage map cell.	DT&E	CI	4.1	N/A
57.0	3.4.2	To calculate a "reasonable" altitude floor, the distance "m" from the sensor to the radar horizon shall be calculated and then the altitude floor for a TIS coverage map cell at a given range "r" shall be computed: R4_3 = 4 * R / 3 m = sqrt((2 * SALT * R4_3) + SALT**2) where "R" is the radius of the Earth and "SALT" is the sensor antenna height in feet above MSL (a sensor surveillance SAP). alt_floor = sqrt(R4_3**2 + (r - m)**2) - R4_3 The altitude floor shall be truncated to .25nm, and rounded to the nearest 1000 ft.	DT&E	CI	4.1	N/A
58.0	3.4.2	Upon completion of the initialization process for the TIS coverage map, the flag controlling the sensor-TIS surveillance interface shall be set TRUE, enabling the interface.	DT&E	CI	4.1	N/A
59.0	3.4.3	The TIS zenith cone table shall be precomputed during initialization.	DT&E	CI	4.1	N/A
60.0	3.4.3	The TIS zenith cone table shall be indexed by altitude and shall return the slant range inside which a goodbye message needs to be sent.	DT&E	CI	4.1	N/A

Req. #	Spec Para	Requirement Text	Test Phase	Verification Method	Test Report Verification Paragraph	Test Scenario or Live Flight
61.0	3.4.3	A range "buffer" shall be added to the table entries in the TIS zenith cone table.	DT&E	CI	4.1	N/A
62.0	3.4.3	The range buffer shall be 0.5 nautical miles for altitudes below 10,000 feet and 1.0 nautical miles for higher altitudes.	DT&E	CI	4.1	N/A
63.0	3.4.3	The initialization of the TIS zenith cone table shall be based on the value of the TIS zenith cone angle SAP (denoted ZCONE here).	DT&E	CI	4.1	N/A
64.0	3.4.3	The sensor altitude SAP from surveillance (denoted SALT here) shall be used in the initialization of the TIS zenith cone table.	DT&E	CI	4.1	N/A

65.0	3.4.3	The initialization of the TIS zenith cone table shall be performed as follows:
		sin_cone = sin(ZCONE)
		cos_cone = cos(ZCONE)
		FOR all altitudes in table DO
		IF (altitude < SALT) THEN table_entry[altitude] = 0
		ELSE
		r = (altitude - SALT) / sin_cone
		IF (altitude < 10000 feet) THEN buffer = 0.5 Nmi
		ELSE buffer = 1.0 Nmi
		temp = 2 * r * buffer * cos_cone
		table_entry[altitude] = sqrt(Sqr(r) + Sqr(buffer) + temp)
			DT&E	CI	4.1	N/A

66.0	3.4.4	The headers of all of the sort list entries (both fast and slow) shall be initialized to the "empty" state upon sensor restart, channel swap, and recovery.	DT&E	CI	4.1	N/A
67.0	3.4.4	TIS track updates in the tracker task processing shall attach active tracks to their appropriate sort list.	OT&E	SD	4.2.19	TISOTLL8
68.0	3.4.5	The headers of all the sector lists shall be initialized to the "empty" state upon sensor restart, channel swap, and recovery.	DT&E	CI	4.1	N/A
69.0	3.4.5	TIS track updates in the tracker task processing shall attach TIS-supported tracks to their appropriate sector list.	OT&E	SD	4.2.19	TISOTLL8
70.0	3.4.6	The conversion of the sensor CPME locations from range-azimuth (denoted R and AZ here) to x-y coordinates shall commence with the calculation of ground range (denoted GR here) from the CPME range and altitude.	DT&E	CI	4.1	N/A

Req. #	Spec Para	Requirement Text	Test Phase	Verification Method	Test Report Verification Paragraph	Test Scenario or Live Flight
71.0	3.4.6	The CPME X and Y coordinates shall be calculated from the CPME azimuth (denoted TH here) as follows: Xpos = GR * sin(TH) Ypos = GR * cos(TH)	DT&E	CI	4.1	N/A
72.0	3.4.6	The computation of the X tolerance shall be performed using the sensor CPME range tolerance SAPs (denoted Rerr here) and the sensor CPME azimuth tolerance SAPs (denoted Aerr here) as follows: x1 = (R + Rerr) * sin(AZ + Aerr) x2 = (R + Rerr) * sin(AZ - Aerr) x3 = (R - Rerr) * sin(AZ + Aerr) x4 = (R - Rerr) * sin(AZ - Aerr) xmin = Minimum(x1,x2,x3,x4) smallest x of the 4 cases xmax = Maximum(x1,x2,x3,x4) largest x of the 4 cases Xerr = (xmax - xmin) / 2 rounded to nearest integer	DT&E	CI	4.1	N/A
73.0	3.4.6	The computation of the Y tolerance shall be performed in an equivalent manner as the X tolerance except that the cosine function shall be used instead of the sine function.	DT&E	CI	4.1	N/A
74.0	3.4.6	The velocity tolerance shall be computed from the sensor ATCRBS 3-sigma range and azimuth parameters (denoted here as R3sigma and A3sigma, which are existing sensor SAPs).	DT&E	CI	4.1	N/A
75.0	3.4.6	The worst-case velocity allowed for a CPME shall be a 3-sigma measurement error over one scan.	DT&E	CI	4.1	N/A
76.0	3.4.6	The calculation of Verr shall be performed as follows: sigA = R * A3sigma(converted to radian measure) Verr = Maximum(sigA,R3sigma) (converted to a per-scan velocity)	DT&E	CI	4.1	N/A
77.0	3.5	The TIS tracker task shall receive inputs from the sensor surveillance processing functions (when TIS is SAP-enabled) and shall maintain the local TIS track file.	OT&E OT&E	SD FT	4.2.12, 4.3.1	TISHOLL4 Live Flt #1
78.0	3.5	Separate tracker algorithms shall be used for the horizontal and vertical (altitude) processing.	DT&E	CI	4.1	N/A
79.0	3.5	TIS tracks that are receiving TIS service (and are in TIS coverage) shall be linked to their appropriate sector lists.	OT&E	SD	4.2.12	TISHOLL4

Req. #	Spec Para	Requirement Text	Test Phase	Verification Method	Test Report Verification Paragraph	Test Scenario or Live Flight
80.0	3.5	The TIS tracker task shall conduct performance monitoring checks on CPME input tracks.	DT&E	CI	4.1	N/A
81.0	3.5	Data extraction shall be performed as required by the sensor data extraction SAPs.	OT&E	SD	4.2.25	TIS4411S
82.0	3.5.1	The interface between the sensor surveillance processing and the TIS tracker task shall be a mailbox that receives inputs of the following types of surveillance data: ATCRBS Track Updates ATCRBS Track Coasts ATCRBS Track Drops Mode S Track Updates Mode S Track Coasts Mode S Track Drops	DT&E	AT	4.2.20	TISHCSP4
83.0	3.5.1	The input messages to the TIS tracker task shall contain the following information elements: Track Number Message Type (indicates ATCRBS or Mode S, Update, Coast, or Drop) CPME flag TIS Request flag Time Range, Azimuth Altitude, Altitude_type (indicates CLEAR_LEVEL, GARBLED, NO_ALT) Mode A code Mode S code (for Mode S messages)	OT&E	FT	4.3.1	Live Flt #1
84.0	3.5.1	The position, altitude, and time values shall be taken from the surveillance track file entry after it has been updated by the input report (for update messages), and from the surveillance track (for coast and drop messages).	OT&E	SD	4.2.12	TISHOLL4
85.0	3.5.1	The TIS-sensor surveillance interface shall monitor a flag variable that is controlled by TIS initialization processing.	DT&E	CI	4.1	N/A
86.0	3.5.1	No surveillance messages shall be sent to the TIS interface mailbox when the flag value is FALSE.	DT&E	CI	4.1	N/A
87.0	3.5.2	The input handler of the TIS tracker task shall wait to receive a message from the sensor surveillance processing through the interface mailbox.	DT&E	CI	4.1	N/A

Req. #	Spec Para	Requirement Text	Test Phase	Verification Method	Test Report Verification Paragraph	Test Scenario or Live Flight
88.0	3.5.2	If the message is an ATCRBS type, the tracker task shall update the TIS track and sort bin linkages for the surveillance track being processed.	OT&E	SD	4.2.24	TIS200
89.0	3.5.2.1	If the input ATCRBS type message indicates a track drop, then the TIS track file entry for the track being processed shall be re-initialized to its default state and the track shall be removed from the sort bin list to which it is currently linked.	DT&E	AT	4.2.25	TIS4411S
90.0	3.5.2.1	If the input ATCRBS type message is not a track drop, the input handler shall compute a set of update time periods for the horizontal and vertical trackers using the input message time as "curr_time": dtime_h = curr_time - TRACK.last_upd_time horizontal update dtime_v = curr_time - TRACK.alt_upd_time vertical update dtime_trans = curr_time - TRACK.alt_trans_time altitude transition time	DT&E	AT	4.2.7	TISCRLL8
91.0	3.5.2.1	If either dtime_h or dtime_v is less than or equal to zero, or dtime_trans is equal to zero (indicating a software timing problem), no further track update processing shall be done.	DT&E	CI	4.1	N/A
92.0	3.5.2.1	If all time computed time periods are positive, the input handler shall proceed to compute a vertical position "ZR" from the message altitude if the message is a track update and the altitude type is CLEAR_LEVEL.	DT&E	AT	4.2.7	TISCRLL8
93.0	3.5.2.1	If the ATCRBS type message is a coast or drop, or the altitude type is not CLEAR_LEVEL, ZR shall be set to the TIS track's vertical position TRACK.ZP (if the TIS track is not in its initial state), or to the lesser of 0.5 nautical miles and one-half of the track's range (if the TIS track is in its initial state).	DT&E DT&E	AT CI	4.2.20 4.1	TISHCSP4 N/A
94.0	3.5.2.1	If the TIS track has seen at least two updates since its initiation, the TIS altitude tracker shall be called to perform the vertical update.	DT&E	AT	4.2.3	TISCRCL8
95.0	3.5.2.1	If the TIS track has seen at least two updates and the horizontal update period is at least 2 seconds, the TIS track horizontal positions (both internal and external) shall be projected to the current time as follows: dx = dtime_h * TRACK.XDI dy = dtime_h * TRACK.YDI TRACK.XPI = TRACK.XPI + dx TRACK.XPE = TRACK.XPE + dx TRACK.YPI = TRACK.YPI + dy TRACK.YPE = TRACK.YPE + dy	DT&E	AT	4.2.3	TISCRCL8

Req. #	Spec Para	Requirement Text	Test Phase	Verification Method	Test Report Verification Paragraph	Test Scenario or Live Flight
96.0	3.5.2.1	After a TIS track has been projected horizontally, any required changes to the TIS track sort bin linkages shall be performed, based on the projected.	DT&E	AT	4.2.3	TISCRCL8
97.0	3.5.2.1	If the input ATCRBS type message is a coast, the internal and external TIS track firmness' (TRACK.FIRMI and TRACK.FIRME) shall be updated according to the following table: Current Track Firmness — Firmness after Coast 0 — 0 1 — 1 2 — 2 3 — 2 4 — 2 5 — 3 6 — 4 7 — 5 8 — 6 9 — 7	DT&E DT&E	AT CI	4.2.20 4.1	TISHCSP4 N/A
98.0	3.5.2.1	If the input ATCRBS type message is a track update, the input handler shall convert the report coordinates from range-azimuth to x-y.	DT&E	AT	4.2.12	TISHOLL4
99.0	3.5.2.1	The first step in the conversion to x-y shall be to calculate the report ground range using the report vertical position ZR.	DT&E	AT	4.2.12	TISHOLL4
100.0	3.5.2.1	Two altitude consistency checks shall be performed as follows: 1) If the absolute value of the difference between ZR and the TRACK.ZP is greater than 9000 feet, then TRACK.ZP shall be used instead of ZR in computing ground range. 2) If the altitude rate (absolute altitude difference divided by the altitude update period "dtime_v") is greater than or equal to 85 feet/second, then TRACK.ZP shall be used instead of ZR in computing ground range.	DT&E	CI	4.1	N/A
101.0	3.5.2.1	Ground range and the input report azimuth shall be used to compute the report x-y coordinates (denoted REPORT.XR, REPORT.YR here).	DT&E	AT	4.2.10	TISHODS5
102.0	3.5.2.1	If the input ATCRBS type message is a track update, the TIS horizontal tracker shall be called to update the horizontal components of the TIS track.	DT&E	AT	4.2.10	TISHODS5
103.0	3.5.2.1	After invoking the TIS horizontal tracker, any necessary changes in the TIS track sort bin linkages shall then be performed.	DT&E	AT	4.2.10	TISHODS5

Req. #	Spec Para	Requirement Text	Test Phase	Verification Method	Test Report Verification Paragraph	Test Scenario or Live Flight
104.0	3.5.2.1	If the track is flagged as a CPME track, performance monitor tracker checks shall be performed.	DT&E	CI	4.1	N/A
105.0	3.5.2.1	Data extraction of reports and/or tracks shall be performed as required.	OT&E	SD	4.2.10	TISHODS5
106.0	3.5.2.2	If the input message is a Mode S type track drop, then the TIS track shall be removed from its sector list and the number of TIS-requesting aircraft shall be decremented.	DT&E DT&E	CI AT	4.1 4.2.25	N/A TIS4411S
107.0	3.5.2.2	If the input message is a Mode S type track drop, the track shall be removed from the sort bin list to which it is currently linked.	DT&E	AT	4.2.25	TIS4411S
108.0	3.5.2.2	If the input message is a Mode S type but not a track drop, the same projection, horizontal tracking, and vertical tracking algorithms that are performed on ATCRBS track update and coast inputs shall be performed for Mode S tracks.	DT&E	AT	4.2.25	TIS4411S
109.0	3.5.2.2	If the input Mode S track is not flagged as currently receiving TIS, the input handler shall check whether it was flagged for receiving TIS on the previous update.	OT&E	FT	4.3.2	Live Flt #2
110.0	3.5.2.2	If the input Mode S track is not flagged as currently receiving TIS, but was flagged for receiving TIS on the previous update, and a "goodbye" message was already sent to the aircraft being processed (as indicated by a flag in the TIS track file entry), the processing shall remove the track being processed from its sector lists and the number of TIS-requesting aircraft shall be decremented.	OT&E	FT	4.3.2	Live Flt #2
111.0	3.5.2.2	If the input Mode S track is not flagged as currently receiving TIS and the "goodbye" message has not been sent yet, the flag in the TIS track shall be set to indicate that a "goodbye" message should be sent immediately.	OT&E	FT	4.3.2	Live Flt #2
112.0	3.5.2.2	If the input Mode S track update or coast is flagged as currently receiving TIS service, the input handler shall compare the current position of the aircraft (via the target range and azimuth) with the TIS coverage map.	OT&E	SD	4.2.7	TISCRLL8
113.0	3.5.2.2	If the input Mode S track update or coast is flagged as currently receiving TIS service, and the Mode S aircraft is not now in TIS coverage (either horizontally or below the altitude floor), a "goodbye" message shall be flagged for transmission to the aircraft.	OT&E	SD	4.2.25	TIS4411S
114.0	3.5.2.2	The "goodbye" message for an aircraft flagged as currently receiving TIS service shall be processed as described for aircraft not currently flagged as receiving TIS. An aircraft whose altitude is not CLEAR_LEVEL shall be considered to be out of coverage.	OT&E	SD	4.2.25	TIS4411S
114.5	3.5.22	An aircraft whose altitude is not CLEAR_LEVEL shall be considered to be out of	OT&E	SD	4.2.20	TISHCSP4

Req. #	Spec Para	Requirement Text	Test Phase	Verification Method	Test Report Verification Paragraph	Test Scenario or Live Flight
		coverage.				TISHCSPX
115.0	3.5.2.2	If the input Mode S track update or coast is flagged as currently receiving TIS service, a check shall be performed to determine if the Mode S aircraft has flown into the zenith cone using the precomputed TIS zenith cone table.	OT&E OT&E	SD FT	4.2.25 4.3.2	TIS4411S Live Flt #2
116.0	3.5.2.2	Mode S aircraft flagged as currently receiving TIS service and flying into the zenith cone shall receive "goodbye" messages.	OT&E OT&E	SD FT	4.2.25 4.3.2	TIS4411S Live Flt #2
117.0	3.5.2.2	If the input Mode S track update or coast message corresponds to a track that was not receiving TIS service on the last update, is in TIS coverage, is not in the zenith cone, and the TIS Maximum Aircraft Supported SAP has not been exceeded then the following actions shall be performed: 1) the input Mode S track shall be added to its appropriate sector list 2) the number of TIS-requesting aircraft shall be incremented 3) the input Mode S track shall be flagged to generate a "keep-alive" message once the track reaches the TIS "mature" state 4) a message shall be sent to Data Extraction containing the track's Mode S address and an indication that TIS support is commencing	OT&E	SD	4.2.25	TIS4411S
118.0	3.5.2.2	Upon receipt of an input Mode S track update or coast message for a TIS track currently in coverage, requesting TIS service, and not in the zenith cone, the TIS track shall be moved to its appropriate sector list.	OT&E	SD	4.2.7	TISCRLL8
119.0	3.5.2.2	Upon receipt of an input Mode S track update or coast message for a TIS track currently in coverage, requesting TIS service, and not in the zenith cone, the flags for "goodbye" and "keep-alive" messages shall be cleared.	DT&E	CI	4.1	N/A
120.0	3.5.2.2	Performance monitor timing checks shall be performed on all Mode S tracks whose state is MATURE and which are requesting TIS service.	DT&E	CI	4.1	N/A
121.0	3.5.2.2	Upon completion of all other track update functions following receipt of a Mode S track update, coast, or drop message, the tracker task input handler shall perform any required Data Extraction.	OT&E	SD	4.2.20	TISHCSP4
122.0	3.5.3	The TIS horizontal tracker shall employ an alpha-beta algorithm augmented with a turn detection step.	DT&E	CI	4.1	N/A
123.0	3.5.3	TIS horizontal tracking shall be performed in x-y coordinates.	DT&E	CI	4.1	N/A
124.0	3.5.3	Three updates shall be required to fully initialize a track.	DT&E	CI	4.1	N/A

Req. #	Spec Para	Requirement Text	Test Phase	Verification Method	Test Report Verification Paragraph	Test Scenario or Live Flight
125.0	3.5.3	The tracker shall maintain two sets of positions and velocities -- termed "internal" and "external".	DT&E	CI	4.1	N/A
126.0	3.5.3	A test shall be made in the horizontal tracker that the update period "dtime_h" is at least 2 seconds.	DT&E OT&E	AT SD	4.2.15 4.2.24	TISOTCL8 TIS200
127.0	3.5.3	If the update period "dtime_h" is not at least 2 seconds (indicating a software timing problem), no horizontal track update shall be performed.	DT&E	CI	4.1	N/A
128.0	3.5.3	If the update period "dtime_h" is not at least 2 seconds the TIS track's "last_upd_time" shall NOT be set to the report time.	DT&E	CI	4.1	N/A
129.0	3.5.3.1	The horizontal track update to a TIS track whose horizontal track state is FIRST shall perform the following: 1) set internal x-y track positions to report x-y position 2) set external x-y track positions to report x-y position 3) set track vertical position to report vertical position 4) set track Mode A and/or Mode S identifier codes to report identifier codes 5) set track correlation maturity state to report maturity state 6) if a channel switch has occurred and the track is flagged for TIS service, flag the track to send a "goodbye" message 7) update the horizontal track state to SECOND	DT&E OT&E	AT FT	4.2.25 4.3.2	TIS4411S Live Flt #2
130.0	3.5.3.2	The horizontal track update to a TIS track whose horizontal track state is SECOND shall repeat steps (1) through (5) of the FIRST state above.	DT&E	AT	4.2.25	TIS4411S
131.0	3.5.3.2	If the horizontal track state is SECOND, the horizontal track state shall be updated to THIRD.	DT&E	AT	4.2.25	TIS4411S
132.0	3.5.3.2	If the horizontal track state is SECOND, the track turn_state shall be initialized to NOTURN.	DT&E	AT	4.2.25	TIS4411S
133.0	3.5.3.2	If the horizontal track state is SECOND, the TIS track altitude fields shall be initialized as follows: TRACK.alt_state = INIT TRACK.alt_upd_time = REPORT.time - scantime 1 scan ago TRACK.alt_trend_time = scantime TRACK.alt_trans_time = -scantime TRACK.alt_rate_time = 0 TRACK.resid = 0 TRACK.alt_trans_diff = 0	DT&E	AT	4.2.25	TIS4411S

Req. #	Spec Para	Requirement Text	Test Phase	Verification Method	Test Report Verification Paragraph	Test Scenario or Live Flight
		TRACK.ZD = 0				
134.0	3.5.3.2	If the horizontal track state is SECOND, the altitude field values shall be updated, and the other altitude track fields initialized, by the first call to the TIS altitude tracker.	DT&E	AT	4.2.25	TIS4411S
135.0	3.5.3.2	If the horizontal track state is SECOND, the horizontal tracker shall compute the x-y velocity components: xvel = (REPORT.XR - TRACK.XPE) / dtime_h yvel = (REPORT.YR - TRACK.YPE) / dtime_h	DT&E	AT	4.2.25	TIS4411S
136.0	3.5.3.2	If the horizontal track state is SECOND, a check shall be made that the x-y velocities are reasonable.	DT&E	CI	4.1	N/A
137.0	3.5.3.2	If the horizontal track state is SECOND, if either velocity is greater than or equal to 2000 knots (indicating a software problem, probably in the value of dtime_h), the horizontal track state shall be reset to FIRST, and no further processing shall be done on the track.	DT&E	CI	4.1	N/A

138.0	3.5.3.2	If the horizontal track state is SECOND, if both velocities are less than 2000 knots, the track horizontal velocity values shall be initialized as follows:
		XDI = XDE = xvel
		YDI = YDE = yvel
		TRACK.speed = sqrt(xvel**2 + yvel**2)
		IF (TRACK.speed >= 250 knots) THEN TRACK.speed_flag = 1
		ELSE
		TRACK.speed_flag = 0
			DT&E	AT	4.2.1, 4.2.22	TISXOVRB
						TISHLSP4

139.0	3.5.3.3	If the horizontal track state is not FIRST or SECOND, the horizontal track state shall be set to MATURE.	DT&E	AT	4.2.1	TISXOVRB
140.0	3.5.3.3	If the horizontal track state is now MATURE, the horizontal tracker shall use an alpha-beta smoothing algorithm to update the track horizontal positions.	DT&E	AT	4.2.1	TISXOVRB
141.0	3.5.3.3	If the horizontal track state is now MATURE, a turn detection algorithm shall be used to further update the track velocities if a turn is detected.	DT&E	AT	4.2.1	TISXOVRB
142.0	3.5.3.3	If the TIS track has already had its third update, is requesting TIS service, and a sensor channel switch has occurred, the track shall be flagged to generate a "keep-alive" message.	OT&E	FT	4.3.2	Live Flt #2
143.0	3.5.3.3	If the horizontal track state is now MATURE, and if the TIS track is a CPME, performance monitoring tracker checks shall be performed to ensure that the tracker	DT&E	CI	4.1	N/A

Req. #	Spec Para	Requirement Text	Test Phase	Verification Method	Test Report Verification Paragraph	Test Scenario or Live Flight
		task is performing properly.				
144.0	3.5.3.3.1	The alpha and beta values and updated track firmness values used shall be a function of the track firmness values as defined in the table below: Firmness Alpha Beta New Firmness 0 1.000 0.000 2 1 1.000 1.000 3 2 1.000 1.000 3 3 0.833 0.700 4 4 0.700 0.409 5 5 0.600 0.270 6 6 0.524 0.192 7 7 0.464 0.144 8 8 0.417 0.122 9 9 0.400 0.100 9	DT&E	CI	4.1	N/A
145.0	3.5.3.3.1	A reasonability test shall be applied to the track horizontal speeds.	DT&E	CI	4.1	N/A
146.0	3.5.3.3.1	If the track has appeared to move at an unreasonable speed (i.e. more than 2000 knots), no further smoothing or turn detection shall be performed.	DT&E	CI	4.1	N/A
147.0	3.5.3.3.1	If the track is moving at a reasonable speed, the smoothing and prediction shall be performed using a standard alpha-beta algorithm as described below: test = 2000 knots * dtime_h maximum legal distance allowed DIX = REPORT.XR - TRACK.XPI DIY = REPORT.YR - TRACK.YPI IF (ABS (DIX) < test) AND (ABS (DIY) < test) THEN track speeds will be reasonable, do smoothing and turn detection alpha = alpha(TRACK.FIRMI) beta = beta(TRACK.FIRMI) XA = TRACK.XPI + alpha * DIX YA = TRACK.YPI + alpha * DIY XDA = TRACK.XDI + (beta * DIX / dtime_h) YDA = TRACK.YDI + (beta * DIY / dtime_h) perform turn detection algorithm TRACK.XPI = XA TRACK.YPI = YA DEX = REPORT.XR - TRACK.XPE DEY = REPORT.YR - TRACK.YPE alpha = alpha(TRACK.FIRME) TRACK.XPE = TRACK.XPE + (alpha * DEX)	DT&E	CI	4.1	N/A

Req. #	Spec Para	Requirement Text	Test Phase	Verification Method	Test Report Verification Paragraph	Test Scenario or Live Flight
		TRACK.YPE = TRACK.YPE + (alpha * DEY) update TRACK.FIRMI and TRACK.FIRME				
148.0	3.5.3.3.2	Tracks which have extremely small speeds (indicating an aircraft stopped or taxiing on the ground) shall not go through horizontal velocity update.	DT&E	CI	4.1	N/A
149.0	3.5.3.3.2	The turn threshold D2TH shall be multiplied by a constant "thk" that is chosen from the following table based on the TIS track's firmness: Firmness THK[] entry 0 infinity 1 infinity 2 infinity 3 3.60 4 2.00 5 1.50 6 1.26 7 1.12 8 1.03 9 1.00	DT&E	CI	4.1	N/A

150.0	3.5.3.3.2	After the alpha-beta smoothing is completed but before the track prediction, the horizontal tracker shall perform the turn detection algorithm to update the TIS track horizontal velocities:
		A = (DIX * TRACK.YDI) - (DIY * TRACK.XDI)
		S = sign(A) +1, 0, or -1
		B = TRACK.XDI**2 + TRACK.YDI**2
		IF (B = 0) THEN D2 = infinity D2=square of cross-track distance
		ELSE D2 = A**2 / B
		R2A = XA**2 + YA**2
		V2A = XDA**2 + YDA**2
		TRACK.speed = sqrt(V2A)
		IF (TRACK.speed > 5 knots) THEN
		Compute turn threshold for D2 as a function of track range, speed, and orientation
		STDA = 150 feet radial error expressed in feet
		STDB = 0.002 * sqrt(R2A) tangential error expressed in feet
		vak = sqrt(V2A) expressed in knots
		DTHA = (3.1 * STDA + 1.35 * vak)**2
		DTHB = (3.1 * STDB + 1.35 * vak)**2 – DTHA
		D2TH = DTHA + DTHB * (XA * XDA + YA * YDA)**2 / (V2A * R2A)
			DT&E
			DT&E
				CI
				AT
					4.1
					4.2.1
						N/A
						TISXOVRB

Req. #	Spec Para	Requirement Text	Test Phase	Verification Method	Test Report Verification Paragraph	Test Scenario or Live Flight

		thk = THK(TRACK.FIRMI)
		D2TH = D2TH * thk
		IF (D2 <= D2TH) THEN
		    no turn detected, update velocities
		    TRACK.turn_state = NOTURN
		    TRACK.XDI = TRACK.XDE = XDA
		    TRACK.YDI = TRACK.YDE = YDA
		ELSE
		    turn detected, compute velocity corrections
		    DRX = DIX + dx
		    DRY = DIY + dy
		    C = DRX * XDA + DRY * YDA
		    P = sign(C)
		    CP2 = C**2 / [(DRX**2 + DRY**2) * V2A]
		    CT2 = [cos(20 degree turn)]**2 constant value
		    IF (P * CP2 <= CT2) THEN
		        default turn correction
		        SDT = sin(10 degrees of turn) constant values
		        CDT = cos(10 degrees of turn)
		    ELSE
		        compute turn correction
		        CP = sqrt(CP2)
		        SDT = sqrt[0.5 * (1 - CP)]
		        CDT = sqrt[0.5 * (1 + CP)]
		    TRACK.XDI = XDA * CDT + (S * SDT * YDA)
		    TRACK.YDI = YDA * CDT - (S * SDT * XDA)
		    IF (S = TRACK.turn_state) THEN
		    same direction as last update, extra external turn correction
		    SDEL = sin(15 degrees of turn) constant values
		    CDEL = cos(15 degrees of turn)
		    TRACK.XDE = TRACK.XDI * CDEL + (S * SDEL * TRACK.YDI)
		    TRACK.YDE = TRACK.YDI * CDEL - (S * SDEL * TRACK.XDI)
		    ELSE
		            not same direction as last update
		            TRACK.XDE = TRACK.XDI
		            TRACK.YDE = TRACK.YDI
		            TRACK.turn_state = S				

Req. #	Spec Para	Requirement Text	Test Phase	Verification Method	Test Report Verification Paragraph	Test Scenario or Live Flight
151.0	3.5.3.4	The final function performed in the TIS horizontal tracker shall be to update the TIS track's sort bin linkage for tracks whose horizontal track state is either THIRD or MATURE.	DT&E	AT	4.2.15	TISOTCL8
152.0	3.5.3.4	If the track whose horizontal track state is either THIRD or MATURE has changed speed classification (based on TRACK.speed_flag), or if it has moved from one bin to another (its current x-y bins do not match the saved bin indices from the track (TRACK.xbin, TRACK.ybin)), then its sort bin linkages shall be updated.	DT&E	AT	4.2.22	TISHLSP4
153.0	3.5.4	The TIS altitude tracker states shall be: INITIALIZE initial state, first time for track or after re-initialization GUESS a single unreinforced altitude transition, rate uncertain TREND an altitude trend has been declared LEVEL level flight RESET need to reset the rate, residual got too large TOZERO reducing rate towards zero	DT&E	CI	4.1	N/A
154.0	3.5.4.1	The overall driver for the TIS altitude tracker shall first compute the altitude that the TIS track would have if projected to the current time: coast_alt = TRACK.ZPR + (dtime_z * TRACK.ZD)	DT&E	AT	4.2.15	TISOTCL8
155.0	3.5.4.1	If the report for the current update does not have a clear flight-level altitude, or if the current update is a coast, then the TIS track's vertical position shall be set to 'coast_alt' and the following check for excessive altitude coasting performed: IF (dtime_z > 4 scans THEN track has coasted too long, reset its altitude fields TRACK.alt_state = INIT TRACK.alt_trend_time = scantime TRACK.alt_trans_time = -scantime TRACK.alt_rate_time = 0 TRACK.resid = 0 TRACKalt_trans_diff = 0 TRACK.ZD = 0 TRACK.have_alt = FALSE If the check passes and the TIS track's altitude fields are reset, no further altitude processing is performed.	DT&E	AT	4.2.20	TISHCSP4
156.0	3.5.4.1	If further altitude processing is to be performed, the TIS altitude tracker driver shall set variables to be used by the processing for the various altitude tracker states. trans_diff = REPORT.ZR - TRACK.ZPR	DT&E	AT	4.2.15	TISOTCL8

Req. #	Spec Para	Requirement Text	Test Phase	Verification Method	Test Report Verification Paragraph	Test Scenario or Live Flight
		TRACK.alt_trans_diff = trans_diff trans_sign = sign(trans_diff) climbing (+), descending (-), or level (0) atrans_diff = |trans_diff| trans_rate = trans_diff / dtime_trans IF (atrans_diff >= 1 flight level) THEN trans_flag = TRUE ELSE trans_flag = FALSE				
157.0	3.5.4.1	If the TIS track's altitude state is INITIALIZE, then the processing for the initialization state shall be performed.	DT&E	AT	4.2.15	TISOTCL8

158.0	3.5.4.1	If the TIS track's altitude state is not INITIALIZE, the TIS altitude tracker shall check that the altitude acceleration is reasonable:
		alt_diff = |coast_alt – REPORT.ZR|
		IF (alt_diff > 6000 feet) THEN
		altitude jump too large, treat as a coast and do no further processing
		accel = 2 * (alt_diff - 1 flight level) / dtime_z**2
		IF (accel > 64 feet/sec**2) THEN
		acceleration too large (> 2 g), treat as a coast , do no further processing
			DT&E	CI	4.1	N/A

159.0	3.5.4.1	If further altitude processing is to be performed, if the value of "trans_flag" is TRUE, then the Transition State update procedure shall be performed -- otherwise, the No Transition State update procedure shall be performed.	DT&E	AT	4.2.10	TISHODS5
160.0	3.5.4.1	If the TIS track's altitude state after the Transition State or No Transition State procedures is TREND and the absolute value of the track's altitude residual is greater than 105 ft, then the RESET Smoothing procedure shall be performed.	DT&E	CI	4.1	N/A

161.0	3.5.4.1	For both the INITIALIZATION and other altitude track states (unless the track has been coasted in altitude), the following shall be performed to complete the altitude tracking function:
		IF (trans_flag = TRUE) THEN
		start of an altitude transition
		TRACK.alt_trans_time = REPORT.time
		TRACK.alt_direction = trans_sign
		TRACK.alt_rate_time = REPORT.time - TRACK.alt_upd_time
		TRACK.alt_upd_time = REPORT.time
		TRACK.ZP = TRACK.ZPR = REPORT.ZR
		IF (TRACK.alt_trend_time > 16 seconds) THEN
		TRACK.alt_trend_time = 16 seconds limit trend duration
		dt = REPORT.time - TRACK.alt_trend_time
		IF (TRACK.alt_trans_time < dt) THEN TRACK.alt_trans_time = dt
			DT&E	AT	4.2.10	TISHODS5

Req. #	Spec Para	Requirement Text	Test Phase	Verification Method	Test Report Verification Paragraph	Test Scenario or Live Flight

162.0	3.5.4.2	The processing for a TIS track whose altitude state is being initialized shall be performed as follows:
		IF (atrans_diff > 1 flight level) THEN
		have had a significant altitude change
		TRACK.alt_state = GUESS unsure about altitude rate
		TRACK.alt_trend_time = 0.2 * scantime assume a time
		TRACK.ZD = ((atrans_diff - 0.75 flight levels) * trans_sign) / dtime_trans
		TRACK.residual = 0.85 * TRACK.residual + TRACK.alt_trans_diff -(TRACK.ZD * dtime_z)
		ELSE
		basically level, no significant altitude change
		TRACK.alt_trend_time = TRACK.alt_trend_time - TRACK.alt_rate_time
		IF (REPORT.alt_type = CLEAR_LEVEL) THEN
		IF (dtime_trans > 6 seconds) THEN TRACK.alt_state = LEVEL
			DT&E	AT	4.2.10	TISHODS5

163.0	3.5.4.3	The processing for a TIS track update during which there has not been an altitude transition shall be performed as follows:
		dtime = dtime_trans - [1 flight level /(|TRACK.ZD| + 1.e-10)] no div. by 0
		IF (dtime > 2.5 * scantime) THEN TRACK.alt_state = TOZERO
		IF (dtime_trans > 15 seconds) THEN TRACK.alt_state = LEVEL
		IF (TRACK.alt_state = RESET) THEN TRACK.alt_state = TREND
		IF (TRACK.alt_state != TREND) THEN
		TRACK.ZD = 0.7 * TRACK.ZD reduce the vertical velocity
		TRACK.alt_trend_time = TRACK.alt_trend_time + dtime_z
		smooth the altitude residual
		TRACK.residual = 0.85 * TRACK.residual + TRACK.alt_trans_diff - (TRACK.ZD * dtime_z)
			DT&E	AT	4.2.13	TISHOLL8

164.0	3.5.4.4	The altitude tracker processing described below shall be performed for a TIS track whose updating report indicates an altitude level transition has occurred since the last update:
		CASE RESET:
		TRACK.alt_state = TREND become a trend
		CASE TREND:
		adjust trend time at start of acceleration
		IF (trans_sign = TRACK.alt_direction) THEN
		IF (TRACK.alt_trend_time > 10 seconds) THEN
		check for early altitude transition
			DT&E
			DT&E
				CI
				AT
					4.1
					4.2.9
						N/A
						TISHOCL8

Req. #	Spec Para	Requirement Text	Test Phase	Verification Method	Test Report Verification Paragraph	Test Scenario or Live Flight

		azd = 1.0 / (|TRACK.ZD| + 1.e-10) no divide by zero
		        dt = (1 flight level * dtime_trans / atrans_diff) - (1 flight level * azd)
		    IF (dt < (-1.42 * scantime + TRACK.alt_guess_time)) THEN
		        reset needed due to early altitude transition
		        TRACK.alt_state = RESET
		        TRACK.residual = 0
		        TRACK.alt_trend_time = dtime_trans + (0.2 * scantime)
		        smooth the altitude residual
		        TRACK.ZD = (0.15 * TRACK.ZD) + (0.85 * trans_rate)
		        smooth the vertical velocity
		        beta = 1.0 / (1.0 + 0.75 * TRACK.alt_trend_time / dtime_trans)
		    IF (beta < 0.1) THEN beta = 0.1
		    TRACK.ZD = (TRACK.ZD * (1.0 - beta)) + (beta * trans_rate)
		    smooth the altitude residual
		    TRACK.residual = 0.85 * TRACK.residual + TRACK.alt_trans_diff -
		    (TRACK.ZD * dtime_z)
		    TRACK.alt_trend_time = TRACK.alt_trend_time + dtime_z
		CASE LEVEL:
		    TRACK.residual = 0
		    TRACK.alt_trend_time = dtime_z
		    IF (atrans_diff > 1 flight level) THEN
		        Beginning of an altitude trend
		        TRACK.alt_state = TREND
		        time = dtime_z + TRACK.alt_guess_time
		        TRACK.ZD = TRACK.alt_trans_diff / time
		    ELSE
		        have to guess at the altitude rate
		        TRACK.alt_state = GUESS
		        TRACK.ZD = (0.25 flight levels) * trans_sign / dtime_trans
		CASE GUESS: same processing for both GUESS and TOZERO states
		CASE TOZERO:
		    IF (trans_sign = TRACK.alt_direction) THEN
		        current trend is continuing
		        TRACK.alt_state = RESET
		        time = (0.2 * scantime) + (0.5 * TRACK.alt_guess_time)
		        IF (atrans_diff > 1 flight level) THEN
		            time = time + dtime_z
		            TRACK.alt_trend_time = dtime_z
		        ELSE
		            time = time + dtime_trans
		            TRACK.alt_trend_time = dtime_trans
		        TRACK.ZD = TRACK.alt_trans_diff / time
		    ELSE				

Req. #	Spec Para	Requirement Text	Test Phase	Verification Method	Test Report Verification Paragraph	Test Scenario or Live Flight
		trend is changing, reset velocity TRACK.ZD = 0 TRACK.alt_trend_time = 0.2 * scantime TRACK.alt_state = GUESS TRACK.residual = 0 TRACK.alt_guess_time = (dtime_z - scantime) * atrans_diff / (1 flight level)				
165.0	3.5.4.4	No processing shall be done for the INITIALIZE altitude state (it should never be encountered at this point in the altitude tracker processing).	DT&E	CI	4.1	N/A

166.0	3.5.4.5	The altitude tracker processing shall be performed as described below for a TIS track whose altitude residual exceeds 105 feet (indicating a missed transition):
		IF (trans_sign != TRACK.alt_direction) THEN
		altitude change is zero or other direction, reset rate towards zero
		TRACK.alt_state = TOZERO
		TRACK.residual = 0
		TRACK.alt_trend_time = dtime_trans
		test_rate = 1 flight level / dtime_trans
		IF (atrans_diff > 1 flight level) THEN
		TRACK.ZD = 0.1 * test_rate * trans_sign reset the vertical rate
		ELSE
		small change in altitude (less than 1 flight level)
		IF (|TRACK.ZD| >= test_rate) THEN
		trate = 0.6 * test_rate * sign(TRACK.ZD)
		TRACK.ZD = TRACK.ZD - trate
		ELSE
		TRACK.ZD = 0.4 * TRACK.ZD
		ELSE
		altitude change consistent with last update, reset rate
		TRACK.alt_state = RESET
		TRACK.residual = 0.15 * TRACK.residual
		TRACK.alt_trend_time = dtime_trans - (0.2 * scantime)
		test_rate = trans_rate - TRACK.ZD
		IF (|test_rate| > 1.3 flight levels / scantime) THEN
		"alpha-beta" smooth the vertical velocity
		temp = (1 flight level * sign(test_rate))
		TRACK.ZD = 0.85 * (TRACK.alt_trans_diff - temp) / dtime_z
		ELSE
		TRACK.ZD = (0.15 * TRACK.ZD) + (0.85 * trans_rate)
			DT&E	CI	4.1	N/A

Req. #	Spec Para	Requirement Text	Test Phase	Verification Method	Test Report Verification Paragraph	Test Scenario or Live Flight
167.0	3.5.4.5	The vertical velocity and residual shall be modified, depending on whether the current altitude direction (up, down, or level) is consistent with the previous altitude update for the TIS track being processed.	DT&E	CI	4.1	N/A
168.0	3.5.5	TIS tracks that indicate a request for TIS service (i.e. TRACK.tis_req_flag = TRUE) shall be linked to the sector list appropriate for their azimuth sector as the last step in the TIS tracker task.	OT&E	SD	4.2.6	TISCRLL4
169.0	3.5.5	The TIS tracks that are linked to a sector list shall be further processed at a later time by the TIS alert generation task.	OT&E	SD	4.2.6	TISCRLL4
170.0	3.5.5	TIS tracks that do not indicate a request for TIS service shall not be linked to a sector list and shall receive no further TIS processing.	OT&E OT&E	FT FT	4.3.1 4.3.2	Live Flt #1 Live Flt #2
171.0	3.6	The TIS alert generation task shall be executed periodically to process entries from the sector lists and generate any necessary TIS uplink messages.	OT&E	SD	4.2.6	TISCRLL4
172.0	3.6	A system timer function shall be used to invoke the TIS alert generation task after 1 sector delay (i.e. after "scantime / 32") from its last execution.	DT&E	CI	4.1	N/A
173.0	3.6	The task shall process the sector lists that are old enough (more than 90 degrees, 8 sectors).	DT&E	CI	4.1	N/A
174.0	3.6	Upon completion, the TIS alert generation task shall suspend its execution until the next timer interrupt restarts it.	DT&E	CI	4.1	N/A
175.0	3.6.1	The TIS alert generation task driver shall use the current surveillance antenna position to derive the current surveillance processing sector.	DT&E	CI	4.1	N/A
176.0	3.6.1	The "back_sector" shall be calculated as the sector which is 8 sectors previous to the current sector.	DT&E	CI	4.1	N/A
177.0	3.6.1	The driver shall maintain the last sector that the alert generation task has processed.	DT&E	CI	4.1	N/A
178.0	3.6.1	Three conditions are then possible: 1) The last sector processed is the same as the back_sector. 2) The last sector processed is one sector less (modulo 32) than the back_sector. 3) The last sector processed is more than one sector less (modulo 32) than the back_sector.	DT&E	CI	4.1	N/A
179.0	3.6.1	If the last sector processed s the same as the back_sector, the alert generation task	DT&E	CI	4.1	N/A

Req. #	Spec Para	Requirement Text	Test Phase	Verification Method	Test Report Verification Paragraph	Test Scenario or Live Flight
		shall suspend its execution until the next timer interrupt.				
180.0	3.6.1	If the last sector processed is one sector less than the back_sector, the alert generation driver shall process all the tracks linked to the "back_sector" list and update the last-processed sector.	DT&E	CI	4.1	N/A
181.0	3.6.1	If the last sector processed differs from back_sector by more than one, the alert generation driver shall process each of the sector lists starting from the last sector processed plus one (modulo 32) up to and including the "back_sector" list.	DT&E	CI	4.1	N/A
182.0	3.6.1	If the last sector processed differs from back_sector by more than one, the alert generation driver shall process all the tracks linked to each of the included sector lists in turn and, finally, update the last-processed sector.	DT&E	CI	4.1	N/A
183.0	3.6.1	For each TIS track found on a sector list, the alert generation timing test shall be performed for performance monitoring (section 3.8.2).	OT&E	SD	4.2.18	TISOTLL4
184.0	3.6.1	For each TIS track found on a sector list, the coarse screening procedure shall be invoked to find any potential traffic tracks in the TIS track file.	OT&E	SD	4.2.18	TISOTLL4
185.0	3.6.1	Each TIS track found in the coarse screening procedure shall be checked through the alert determination algorithm.	OT&E	SD	4.2.18	TISOTLL4
186.0	3.6.1	The result of the alert determination processing shall be a list of alerts to be uplinked to the TIS aircraft whose track was input from the sector list.	OT&E	SD	4.2.27 above	TIS4422
187.0	3.6.1	For each TIS track found on a sector list, the list of TIS alerts shall be ordered using the TIS alert priority algorithm	OT&E	SD	4.2.27	TIS4422
188.0	3.6.1	For each TIS track found on a sector list, TIS uplink messages shall be formatted based on the list of TIS alerts.	OT&E	SD	4.2.27	TIS4422
189.0	3.6.1	TIS uplink messages other than TIS alerts (i.e. "goodbye" and "keep-alive") may be generated.	OT&E	SD	4.2.27	TIS4422
190.0	3.6.1	For each TIS track found on a sector list, the formatted TIS uplink messages shall be passed on to the sensor software data link interface.	OT&E	SD	4.2.9	TISHOCL8
191.0	3.6.1	For each TIS track found on a sector list, data extraction of the alerts shall be performed if desired.	OT&E	SD	4.2.9	TISHOCL8
192.0	3.6.2	The coarse screening process shall search the TIS track file for those tracks that are close enough in the horizontal direction to potentially generate TIS alerts with the	OT&E	SD	4.2.6	TISCRLL4

Req. #	Spec Para	Requirement Text	Test Phase	Verification Method	Test Report Verification Paragraph	Test Scenario or Live Flight
		input TIS track.				
193.0	3.6.2	Two separate searches shall be performed: one over the "fast" track lists and a second over the "slow" track lists.	DT&E	CI	4.1	N/A
194.0	3.6.2	Each search shall be anchored at the sort bin list (fast or slow) that contains the input TIS track.	DT&E	AT	4.2.21	TISHDSP8
195.0	3.6.2	The fast search shall test all the TIS tracks at the input track's sort bin and those in the eight neighboring sort bins (if the neighboring sort bins exist in the sort list data structure).	DT&E	AT	4.2.21	TISHDSP8
196.0	3.6.2	Each TIS track in the neighboring sort bins shall be tested for alert generation, and any alerts generated shall be stored in separate lists for proximity and threat categories.	DT&E	AT	4.2.27	TIS4422
197.0	3.6.2	The proximity and threat lists shall contain the alert determination taus (for transmission to data extraction) and the square of the range between the input TIS track and the track generating the alert (for use in alert priority ordering).	DT&E	AT	4.2.27	TIS4422
198.0	3.6.2	A check shall be made to avoid finding the input TIS track in the search (since it is on the list for its own bin).	DT&E	AT	4.2.26	TIS4421
199.0	3.6.2	Only TIS tracks whose tracking state is declared MATURE and whose surveillance state is MATURE shall be candidates for alert generation, all non-mature tracks shall be skipped.	DT&E	AT	4.2.26	TIS4421
200.0	3.6.2	If the Terra mode is in effect (by SAP control), then only ATCRBS tracks shall be sent to alert determination.	OT&E	SD	4.2.24	TIS200 NON200
201.0	3.6.2	If the Terra mode is not in effect, both ATCRBS and Mode S tracks shall be sent to alert determination processing.	OT&E	SD	4.2.24	TIS200 NON200
202.0	3.6.2	The slow search shall be equivalent to the fast search described above except that the range of bins to search in the x and y directions shall be determined by the speed of the input TIS track as follows: bins = 1 + Integer(track speed / 250 knots) which may extend beyond the neighboring 8 bins if the input TIS track speed is greater than or equal to 250 knots.	DT&E	AT	4.2.5	TISCRDS8
203.0	3.6.3	The alert determination processing shall be called for each potential alert track found	DT&E	AT	4.2.5	TISCRDS8

Req. #	Spec Para	Requirement Text	Test Phase	Verification Method	Test Report Verification Paragraph	Test Scenario or Live Flight
		during coarse screening.				
204.0	3.6.3	Each potential alert track shall be compared against the input TIS track.	DT&E	AT	4.2.5	TISCRDS8
205.0	3.6.3	If the Terra mode is in effect (by sensor SAP control), then only ATCRBS tracks from the TIS track file shall be considered for potential alerts.	OT&E	SD	4.2.24	TIS200 NON200
206.0	3.6.3	The alert determination shall return one of three conditions: no alert, proximity alert, or threat alert.	DT&E	CI	4.1	N/A
207.0	3.6.3	Any proximity and threat alert tracks shall be stored on independent lists with their range separation and tau values for use in the alert priority ordering.	DT&E	CI	4.1	N/A
208.0	3.6.3	The initial stage of alert determination shall compute the differences in x and y-direction position and velocity (denoted here as "dx, dy, dvx, dvy") using the TIS track's "external" values.	DT&E	AT	4.2.5	TISCRDS8
209.0	3.6.3	If both tracks in alert determination have a clear altitude value, then the altitude difference (denoted here as "dz") and the absolute value of the altitude difference shall be calculated (denoted here as "dalt").	DT&E	AT	4.2.5	TISCRDS8
210.0	3.6.3	If either track in alert determination lacks a clear altitude value, then the following values shall be used: dz = dalt = 0.	DT&E	AT	4.2.20	TISHCSP4
211.0	3.6.3.1	If the Terra mode is in effect (by SAP control), then the alert determination process shall perform additional checks to prevent the ATCRBS TIS track on the input aircraft from generating an alert against the Mode S form of the TIS input track (in order to prevent "self-alerts").	OT&E	SD	4.2.9	TISHOCL8 NONHOCL8
212.0	3.6.3.1	A flag variable (denoted "duplicate") shall be used to insure that only one potential alert may be eliminated by the Terra checking.	DT&E	CI	4.1	N/A
213.0	3.6.3.1	The "duplicate" flag shall be initialized FALSE in the alert generation task handler.	DT&E	CI	4.1	N/A
214.0	3.6.3.1	If "duplicate" is FALSE (indicating that the ATCRBS duplicate track has not yet been encountered), the absolute values of the range and azimuth differences between the input TIS track and the potential alert track shall be calculated.	DT&E	CI	4.1	N/A
215.0	3.6.3.1	If "duplicate" is FALSE, and if the absolute range difference is greater than 0.1 nautical mile (20 RU), or if the absolute azimuth difference is greater than 0.88 degrees (40 AU), then the potential alert track shall not be considered a potential duplicate and Terra checking for the pair of tracks shall be complete.	DT&E	CI	4.1	N/A

Req. #	Spec Para	Requirement Text	Test Phase	Verification Method	Test Report Verification Paragraph	Test Scenario or Live Flight
216.0	3.6.3.1	If "duplicate" is FALSE, and Terra checking should continue, an altitude test shall be performed.	DT&E	CI	4.1	N/A
217.0	3.6.3.1	IF Terra altitude testing is to be performed, and if either track lacks a clear altitude, then the altitude difference shall be assumed to be zero.	DT&E	CI	4.1	N/A
218.0	3.6.3.1	IF Terra altitude testing is to be performed, if the absolute value of the altitude difference between the input TIS track and the potential alert track (dalt) is greater than 180 feet, then the potential alert track shall not be considered a potential duplicate condition.	DT&E	CI	4.1	N/A
219.0	3.6.3.1	If "duplicate" is FALSE, and Terra checking should continue because the tracks are sufficiently close in range, azimuth and altitude, further checks shall be performed on code and velocity.	DT&E	CI	4.1	N/A
220.0	3.6.3.1	If further Terra checks are to be performed, and if the input TIS track has a discrete ATCRBS Mode A code and it matches the ATCRBS Mode A code of the potential alert track, then the potential alert track shall be declared a Terra match with the input TIS track.	DT&E	CI	4.1	N/A
221.0	3.6.3.1	If Terra code checks result in a match of discrete Mode A codes, the "duplicate" flag shall be set TRUE, and no further alert determination processing shall be performed.	DT&E	CI	4.1	N/A
222.0	3.6.3.1	If further Terra checks are to be performed, and if the Mode A codes do not match or if the input TIS track did not have a discrete Mode A code (possible in cases of garble or transitioning codes), velocity tests shall be performed.	DT&E	CI	4.1	N/A
223.0	3.6.3.1	If Terra velocity checks are to be performed, the absolute values of the x and y-direction velocity differences between the two tracks shall be calculated.	DT&E	CI	4.1	N/A
224.0	3.6.3.1	If Terra velocity checks are to be performed, if both absolute velocity differences are less than 20 knots (3960 RU's per hour), then the potential alert track shall be declared a Terra match with the input TIS track.	DT&E	CI	4.1	N/A
225.0	3.6.3.1	If the Terra velocity check produces a match, the "duplicate" flag shall be set TRUE, and no further alert determination processing shall be performed.	DT&E	CI	4.1	N/A
226.0	3.6.3.2	The determination of the alert "threat" condition shall be based on the calculation of "time to closest approach", denoted as "tau", along with the horizontal and vertical separations of the aircraft positions.	DT&E	AT	4.2.13	TISHOLL8
227.0	3.6.3.2	The horizontal tau shall be calculated as follows:	DT&E	AT	4.2.13	TISHOLL8

Req. #	Spec Para	Requirement Text	Test Phase	Verification Method	Test Report Verification Paragraph	Test Scenario or Live Flight

		r2 = dx**2 + dy**2 square of separation, saved for sorting later
		dot = dx*dvx + dy*dvy dot product of velocity vectors
		IF (dot = 0) THEN th = -1 protect against "divide by zero" - force divergence
		ELSE
		th = -r2 / dot calculate horizontal tau				

228.0	3.6.3.2	The determination of a threat condition shall be performed as follows:
		IF (In_range(th,120 seconds)) OR (r2 < 1.5 Nmi**2) THEN
		horizontal O.K., now check vertical direction
		IF (both tracks have clear altitude) THEN
		dvz = potential track's ZD - input TIS track's ZD
		IF (dvz = 0) THEN tv = -1 "divide by zero" – force divergence
		ELSE
		tv = -dz / dvz calculate vertical tau
		ELSE
		tv = 1 aircraft assumed converging, small tau
		IF (In_range(tv,120 seconds)) OR (dalt < 1200 feet) THEN
		altitudes too close already, or converging
		IF (In_range(th,34 seconds)) OR (r2 < 0.5 Nmi**2) THEN
		ranges too close already or converging
		IF (In_range(tv,34 seconds)) OR (dalt < 800 feet) THEN
		declare a threat condition where we define the following "short-hand" notation:
		In_range(x,p) := (x > 0) AND (x < p)
			DT&E	AT	4.2.13	TISHOLL8

229.0	3.6.3.2	Secondary tests for proximity shall be made to override any potential problems with the tau calculations.	DT&E	CI	4.1	N/A
230.0	3.6.3.3	If the threat determination tests fails, then testing for a proximity alert shall be performed as follows: IF (dalt < 1200 feet) AND (r2 < 5 Nmi**2) THEN declare proximity alert	DT&E	CI	4.1	N/A
231.0	3.6.4	The alert priority ordering process shall take in the two lists of alerts (proximity and threat) generated by the alert determination processing and merge them into a single list of alerts according to a priority ordering.	OT&E	SD	4.2.28	TIS4423
232.0	3.6.4	All threat alerts shall be prioritized ahead of proximity alerts.	OT&E	SD	4.2.28	TIS4423

Req. #	Spec Para	Requirement Text	Test Phase	Verification Method	Test Report Verification Paragraph	Test Scenario or Live Flight
233.0	3.6.4	Within an alert category, alerts shall be prioritized in order of increasing range separation.	OT&E	SD	4.2.28	TIS4423
234.0	3.6.4	A maximum of 8 alerts shall be merged onto the output list.	OT&E	SD	4.2.29	TIS4424
235.0	3.6.4	The output alert list shall be sent to the message formation processing.	OT&E	SD	4.2.29	TIS4424
236.0	3.6.4	Each of the input lists shall first be sorted by the range separation (squared) in ascending order.	DT&E	AT	4.2.28	TIS4423
237.0	3.6.4	If the range separations (squared) of two or more alerts in the input list are equal, the earlier-occurring alerts in the input list shall go first in the sorting.	DT&E	AT	4.2.28	TIS4423
238.0	3.6.4	Up to eight alerts from the sorted threat list shall be added to the output list.	DT&E	CI	4.1	N/A
239.0	3.6.4	If room remains in the output list, then alerts from the sorted proximity list shall be added to the output list.	OT&E	SD	4.2.29	TIS4424
240.0	3.6.4	The output list entries shall contain the following elements: TIS track index TIS alert state (threat / proximity) threat horizontal tau (unused for proximity) threat vertical tau (unused for proximity)	DT&E	CI	4.1	N/A
241.0	3.6.4	The tau values shall be passed to data extraction.	OT&E	SD	4.2.13	TISHOLL8
242.0	3.6.5	TIS uplink messages shall each consist of 56 bits (a Mode S Comm-A).	OT&E OT&E	SD FT	4.2.17 4.3.1, 4.3.2	TISOTDS8 Live Flt # 1, 2
243.0	3.6.5	The first 8 bits of each TIS uplink message shall be the Mode S Specific Protocol (MSP) header.	OT&E OT&E	SD FT	4.2.17 4.3.1, 4.3.2	TISOTDS8 Live Flt # 1, 2
244.0	3.6.5	The MSP header shall have the value 02 hexadecimal for all TIS messages, indicating a short-form MSP packet using MSP channel number 2.	OT&E OT&E	SD FT	4.2.17 4.3.1, 4.3.2	TISOTDS8 Live Flt # 1, 2
245.0	3.6.5	The next 6 bits of the TIS uplink message shall contain the message type field.	OT&E OT&E	SD FT	4.2.17 4.3.1, 4.3.2	TISOTDS8 Live Flt # 1, 2
246.0	3.6.5	The remainder of the TIS uplink message shall contain two Traffic Data Blocks.	OT&E	SD	4.2.17	TISOTDS8

Req. #	Spec Para	Requirement Text	Test Phase	Verification Method	Test Report Verification Paragraph	Test Scenario or Live Flight
			OT&E	FT	4.3.1, 4.3.2	Live Flt # 1, 2
247.0	3.6.5	A maximum of four TIS uplink messages shall be generated by message formation processing for a given TIS-requesting aircraft.	DT&E	CI	4.1	N/A
248.0	3.6.5	The list of TIS uplink messages shall be passed to the sensor data link functions.	OT&E	SD	4.2.9	TISHOCL8
249.0	3.6.5	Message Formation processing shall first check whether a goodbye message is flagged for the track being processed.	OT&E	SD	4.2.25	TIS4411S
250.0	3.6.5	If a goodbye message is flagged for the track being processed, the goodbye message shall be formatted and sent to the sensor data link interface.	OT&E	SD	4.2.25	TIS4411S
251.0	3.6.5	If a goodbye message is indicated, the last TIS update time in the TIS track shall be set to the time of the latest track update: TRACK.last_uplink_time = TRACK.last_upd_time	DT&E	CI	4.1	N/A
252.0	3.6.5	If no goodbye is indicated for the track being processed, message formation processing shall check whether there are any traffic alert messages for the track.	OT&E	SD	4.2.9	TISHOCL8
253.0	3.6.5	If there are traffic alert messages for the track being processed, they shall be formatted and passed to the sensor data link functions.	OT&E	SD	4.2.9	TISHOCL8
254.0	3.6.5	If there are an odd number of traffic alert messages, the second Traffic Data Block of the last traffic alert message shall not contain traffic data.	OT&E	SD	4.2.5	TISCRDS8
255.0	3.6.5	To indicate the presence of an odd number of alerts, the traffic bearing field in the last message shall be set to 63 and the remaining 15 bits shall be unused and shall be cleared to zero.	OT&E	SD	4.2.5	TISCRDS8
256.0	3.6.5	If there are traffic alert messages, the TIS track's last TIS update time shall be reset as described for the goodbye message, and the TIS message sent flag (TRACK.msg_sent_flag) shall be set TRUE to indicate that a traffic update was sent on the current scan.	DT&E	CI	4.1	N/A
257.0	3.6.5	If there were no traffic alert messages for the track being processed (and no goodbye), checks shall be performed to see if a TIS keep-alive message is required.	OT&E	SD	4.2.25	TIS4411S
258.0	3.6.5	The "keep-alive" message tests shall be: tdiff = TRACK.last_upd_time - TRACK.last_uplink_time IF (TRACK.msg_sent_flag) OR (TRACK.new_tis_flag) OR (tdiff >= 60 seconds - scantime) THEN	DT&E	CI	4.1	N/A

Req. #	Spec Para	Requirement Text	Test Phase	Verification Method	Test Report Verification Paragraph	Test Scenario or Live Flight
		send a TIS keep-alive message TRACK.last_uplink_time = TRACK.last_upd_time TRACK.msg_sent_flag = FALSE last message was keep-alive				
259.0	3.6.5.1	TIS Traffic Alert messages shall be composed of the 8-bit MSP header, the 6-bit message type field, and two Traffic Data Blocks, as shown in the following figure: Header / Message Type / Traffic Block 1 / Traffic Block 2 8 / 6 / 21 / 21	OT&E OT&E	SD FT	4.2.2 4.3.1, 4.3.2	TISCRCL4 Live Flt # 1, 2
260.0	3.6.5.1.1	A maximum of 8 traffic alerts for a given TIS-equipped aircraft shall be passed to TIS message formation processing.	OT&E	SD	4.2.29	TIS4424
261.0	3.6.5.1.1	An individual TIS uplink message may contain information on one or two traffic alerts.	OT&E	SD	4.2.26	TIS4421
262.0	3.6.5.1.1	The individual alert messages shall be grouped as indicated in the following table: Number of Traffic Aircraft — Structure of Group 1 — first 2 — first 3 — first, final 4 — first, final 5 — first, intermediate, final 6 — first, intermediate, final 7 — first, intermediates (2), final 8 — first, intermediates (2), final	OT&E	SD	4.2.28	TIS4423
263.0	3.6.5.1.1	The message type field in each message shall indicate the type of the message in the group.	OT&E OT&E	SD SD	4.2.25 4.2.26	TIS4411S, TIS4421
264.0	3.6.5.1.1	The first message in each group shall convey the own-aircraft ground track angle.	OT&E	SD	4.2.2	TISCRCL4
265.0	3.6.5.1.1	The "traffic bearing" field in the second of the two Traffic Information Blocks in the final message (or the first message if there is only the first) shall be set to the value 63 if the number of traffic aircraft is odd.	OT&E	SD	4.2.5	TISCRDS8
266.0	3.6.5.1.2	The own-aircraft ground track angle value shall be derived from the own-aircraft surveillance track (denoted OWN here) external horizontal velocities and shall be adjusted to reference Magnetic North using the TIS Magnetic Deviation Angle SAP as follows:	DT&E	CI	4.1	N/A

Req. #	Spec Para	Requirement Text	Test Phase	Verification Method	Test Report Verification Paragraph	Test Scenario or Live Flight

		otrack = ATC_atan2(OWN.XDE,OWN.YDE) + Mag_Dev_Angle_SAP
		IF (otrack >= 360 degrees) THEN otrack = otrack - 360 degrees
		IF (otrack < 0 degrees) THEN ohead = otrack + 360 degrees
		own_track = Integer(otrack / 6 degrees) quantize to 6-degree steps				

267.0	3.6.5.1.2	The value of "own_track" shall be used in the determination of Message Type and Traffic Bearing.	OT&E	SD	4.2.2	TISCRCL4
268.0	3.6.5.1.2	The "atan2()" function shall use the ATC angle convention, measuring angles clockwise from North.	DT&E	CI	4.1	N/A
269.0	3.6.5.1.3	The message type field shall be set to the "own_track" value if the TIS alert message being processed is the first (or only) message in the group for the TIS aircraft being processed.	OT&E	SD	4.2.25	TIS4411S
270.0	3.6.5.1.3	If the TIS alert message being processed is an intermediate message in the group (neither first nor final), then the message type field shall be set to the value 60.	OT&E	SD	4.2.28	TIS4423
271.0	3.6.5.1.3	If the TIS alert message being processed is the final message in the group, then the message type field shall be set to the value 61.	OT&E	SD	4.2.27	TIS4422
272.0	3.6.5.1.3	TIS keep-alive messages shall set the message type value to 63.	OT&E	SD	4.2.4	TISCRDS4
273.0	3.6.5.1.3	TIS goodbye messages shall set the message type value to 62.	OT&E	SD	4.2.25	TIS4411S
274.0	3.6.5.1.4	Each TIS Traffic Data uplink Traffic Data message shall contain two 21-bit Traffic Information Blocks whose structure is shown in the figure below: Traffic Bearing 6 / Traffic Range 4 / Relative Altitude 5 / Altitude Rate 2 / Traffic Heading 3 / Traffic Status 1	OT&E	SD	4.2.26	TIS4421
275.0	3.6.5.1.4	The first step in the generation of a Traffic Data Block is to project the external tracked positions of the traffic track (denoted TRAFFIC here) and the own-aircraft track (denoted OWN here) to the time that the sensor will next see the own-aircraft and the message containing the Traffic Data Block data will be delivered, where the time of the report that updated OWN is denoted REPORT.time, the time required for a sensor scan is denoted "scantime", and the traffic track holds its most recent x-y position update time (denoted TRAFFIC.last_upd_time here) and the most recent altitude update time (denoted TRAFFIC.alt_upd_time here).	DT&E	AT	4.2.18	TISOTLL4
276.0	3.6.5.1.4	The external projection n generating a Traffic Data Block shall be performed using the algorithm below:	DT&E	CI	4.1	N/A

Req. #	Spec Para	Requirement Text	Test Phase	Verification Method	Test Report Verification Paragraph	Test Scenario or Live Flight
		Project traffic position ahead to next scan time dt_horiz = REPORT.time + scantime - TRAFFIC.last_upd_time dt_vert = REPORT.time + scantime - TRAFFIC.alt_upd_time xp = TRAFFIC.XPE + (dt_horiz * TRAFFIC.XDE) yp = TRAFFIC.YPE + (dt_horiz * TRAFFIC.YDE) zp = TRAFFIC.ZP + (dt_vert * TRAFFIC.ZD) Project own-aircraft position ahead to next scan time oxp = OWN.XPE + (scantime * OWN.XDE) oyp = OWN.YPE + (scantime * OWN.YDE) ozp = OWN.ZP + (scantime * OWN.ZD) Compute relative distances from own-aircraft to traffic dx = xp - oxp dy = yp – oyp dz = zp – ozp				
277.0	3.6.5.1.4	The 6-bit Traffic Bearing field shall contain the bearing angle from the own-aircraft to the alert aircraft, quantized in 6-degree increments.	OT&E	SD	4.2.4	TISCRDS4
278.0	3.6.5.1.4	The range for a valid Traffic Bearing field shall be 0 through 59.	OT&E	SD	4.2.4	TISCRDS4
279.0	3.6.5.1.4	The Traffic bearing angle shall be defined by TIS with respect to the sensor-measured own-aircraft ground track.	OT&E	SD	4.2.4	TISCRDS4
280.0	3.6.5.1.4	Traffic Bearing shall be computed as follows: theta = ATC_atan2(dx,dy) ATC-version of atan2() function tbrng = theta – otrack IF (tbrng < 0) THEN tbrng = tbrng + 360 degrees bearing = Integer(tbrng / 6 degrees) quantize bearing to 6-degree steps	DT&E	CI	4.1	N/A
281.0	3.6.5.1.4	If there is only one traffic aircraft used in a given TIS message, the second Traffic Information Block in the TIS message shall not contain valid information.	OT&E	SD	4.2.8	TISHOCL4
282.0	3.6.5.1.4	To indicate there is only one traffic aircraft in the TIS message, the Traffic Bearing field in the unused Traffic Information Block shall be set to the value 63 (representing a bearing angle greater than 360 degrees) and the remainder of the bits in the Traffic Information Block shall be cleared to zero.	OT&E	SD	4.2.8	TISHOCL4
283.0	3.6.5.1.4	The 4-bit Traffic Range field shall contain the distance between the own-aircraft and the alert aircraft.	OT&E	SD	4.2.8	TISHOCL4
284.0	3.6.5.1.4	The calculation of traffic range shall be performed as follows:	DT&E	CI	4.1	N/A

Req. #	Spec Para	Requirement Text	Test Phase	Verification Method	Test Report Verification Paragraph	Test Scenario or Live Flight
		Trange = sqrt(dx**2 + dy**2)				
285.0	3.6.5.1.4	A nonlinear range encoding shall be used to minimize the number of bits required for the Traffic Range field as shown in the following table: Encoding — Trange (in 1/8th nautical mile increments) 0 — 0 <= R <= 1 1 — 1 < R <= 3 2 — 3 < R <= 5 3 — 5 < R <= 7 4 — 7 < R <= 9 5 — 9 < R <= 11 6 — 11 < R <= 13 7 — 13 < R <= 15 8 — 15 < R <= 18 9 — 18 < R <= 22 10 — 22 < R <= 28 11 — 28 < R <= 36 12 — 36 < R <= 44 13 — 44 < R <= 52 14 — 52 < R <= 56 15 — R > 56	DT&E	CI	4.1	N/A
286.0	3.6.5.1.4	For aircraft more than 30 nautical miles from the sensor, the first two range encodings shall be collapsed into the lowest to account for the increased cross-range error at longer ranges (which results in a large uncertainty of the traffic bearing value). IF (OWN.range >= 30 Nmi.) AND (Encoding <= 1) THEN Encoding = 0	DT&E	AT	4.2.19	TISOTLL8
287.0	3.6.5.1.4	The 5-bit Relative Altitude field shall contain the difference in altitude between the own-aircraft and the alert aircraft.	OT&E	SD	4.2.8	TISHOCL4
288.0	3.6.5.1.4	The TIS encoding for Relative Altitude values shall be defined by the following table: Encoding — Relative Altitude (in feet) 0 — 0 <= dz < 100 1 — 100 <= dz < 200 2 — 200 <= dz < 300 3 — 300 <= dz < 400 4 — 400 <= dz < 500 5 — 500 <= dz < 600 6 — 600 <= dz < 700 7 — 700 <= dz < 800 8 — 800 <= dz < 900	DT&E	CI	4.1	N/A

Req. #	Spec Para	Requirement Text	Test Phase	Verification Method	Test Report Verification Paragraph	Test Scenario or Live Flight
		9 900 <= dz < 1000 10 1000 <= dz < 1500 11 1500 <= dz < 2000 12 2000 <= dz < 2500 13 2500 <= dz < 3000 14 3000 <= dz < 3500 15 dz >= 3,500 16 no altitude reported 17 -100 < dz < 0 18 -200 < dz <= -100 19 -300 < dz <= -200 20 -400 < dz <= -300 21 -500 < dz <= -400 22 -600 < dz <= -500 23 -700 < dz <= -600 24 -800 < dz <= -700 25 -900 < dz <= -800 26 -1000 < dz <= -900 27 -1500 < dz <= -1000 28 -2000 < dz <= -1500 29 -2500 < dz <= -2000 30 -3000 < dz <= -2500 31 dz <= -3000				
289.0	3.6.5.1.4	The 2-bit Altitude Rate field shall indicate whether the alert aircraft is climbing (code 1), descending (code 2) , or level (code 3).	OT&E OT&E OT&E	SD SD SD	4.2.18, 4.2.14, 4.2.16	TISOTLL4, TISOTCL4, TISOTDS4
290.0	3.6.5.1.4	An altitude rate of 500 feet per minute shall be used as a threshold.	OT&E	AT	4.2.21	TISHCSP8

291.0	3.6.5.1.4	The calculation of the altitude rate field shall be done as follows:
		dalt = TRAFFIC.ZD convert to feet/minute units
		IF (dalt >= 500 feet per minute) THEN arate = 1
		ELSE
		IF (dalt <= -500 feet per minute) THEN arate = 2
		ELSE arate = 3
			DT&E	CI	4.1	N/A

292.0	3.6.5.1.4	The 3-bit Traffic Heading field shall contain the ground track angle of the alert aircraft quantized to 45-degree (i.e. compass-point) increments.	OT&E	SD	4.2.5	TISCRDS8

Req. #	Spec Para	Requirement Text	Test Phase	Verification Method	Test Report Verification Paragraph	Test Scenario or Live Flight
293.0	3.6.5.1.4	The Traffic Heading field shall be calculated by the following: Theading = Integer(ATC_atan2(TRAFFIC.XDE,TRAFFIC.YDE) / 45 degrees)	DT&E	CI	4.1	N/A
294.0	3.6.5.1.4	The 1-bit Traffic Status field shall identify the type of alert represented by the Traffic Information Block being processed, where a Status value of 0 shall indicate a "proximity" alert, while a Status value of 1 shall indicate a "traffic" alert.	OT&E	SD	4.2.18	TISOTLL4
295.0	3.6.5.2	TIS "keep-alive" messages shall be generated for uplink to aircraft receiving TIS support whenever any of the following conditions occur: a) the previous scan's TIS update for the selected aircraft had traffic and the current update does not (the keep-alive message causes the airborne display to be cleared) b) 60 seconds minus 1 scan interval has elapsed since the previous TIS update for the aircraft being processed (the keep-alive message causes the 60-second airborne timer for TIS support to be reset) c) the TIS-requesting aircraft has entered coverage, its TIS track entry is now mature, and there are no alert uplinks to send the current scan (the keep-alive starts the airborne display)	OT&E OT&E	SD SD	4.2.14 4.2.25	TISOTCL4, TIS4411S
296.0	3.6.5.2	A TIS keep-alive message shall be indicated by the message type value of 63.	OT&E	SD	4.2.4	TISCRDS4
297.0	3.6.5.2	The remaining 42 bits of a TIS keep-alive message uplink shall be unused and shall be cleared to zero.	OT&E	SD	4.2.14	TISOTCL4
298.0	3.6.5.3	TIS "goodbye" messages shall be generated for uplink to aircraft receiving TIS support whenever any of the following conditions occur: a) the TIS-requesting aircraft track has moved out of TIS coverage of the sensor, b) the TIS-requesting aircraft track has moved into the sensor's TIS zenith cone, c) the sensor TIS software is re-initializing after a sensor channel switch, d) more than 2 sensor scans have elapsed since a TIS-requesting aircraft track was last updated by surveillance, either by report update or track coast.	OT&E OT&E	SD FT	4.2.25, 4.2.12 4.3.2	TIS4411S, TISHCSP4 Live Flt #2
299.0	3.6.5.3	A TIS goodbye message shall be indicated by the message type value 62.	OT&E	SD	4.2.25	TIS4411S
300.0	3.6.5.3	The remaining 42 bits of a TIS goodbye message uplink are unused and shall be cleared to zero.	OT&E	SD	4.2.25	TIS4411S
301.0	3.6.6	Any TIS uplink messages produced by the message formation process shall be passed	OT&E	SD	4.2.16	TISOTDS4

Req. #	Spec Para	Requirement Text	Test Phase	Verification Method	Test Report Verification Paragraph	Test Scenario or Live Flight
		on to the sensor software data link function through a mailbox.				
302.0	3.6.6	TIS uplink messages shall utilize the 56-bit Mode S "Comm-A" format.	OT&E	SD	4.2.16	TISOTDS4
303.0	3.6.6	All TIS uplink messages shall use the following common parameter values and procedures for data link: a) Mode S identifier = TRACK.ms_code b) Data Link priority = 10 (assigned by ICAO) c) one scan message delivery expiration time d) no sensor retransmission if TIS message delivery unsuccessful	DT&E	CI	4.1	N/A
304.0	3.6.6	There shall be no retransmission of a TIS uplink message beyond the scan on which it was generated because TIS will generate a new message for the next update.	DT&E	CI	4.1	N/A
305.0	3.6.6	Each TIS uplink message passed to the data link mailbox interface shall be tagged with a unique modulo 16 message number (TRACK.last_msg_no) that shall incremented for each uplink.	DT&E	CI	4.1	N/A
306.0	3.6.6	Message number zero shall not be used as a TIS uplink message number.	OT&E	SD	4.2.16	TISOTDS4
307.0	3.6.6	TIS uplink messages shall not be included in the sensor's data link performance monitor statistics.	DT&E	CI	4.1	N/A
308.0	3.7.1	A TIS-equipped sensor in which TIS is SAP-enabled shall read out the contents of a transponder Mode S extended capability register (GICB register 16) during Mode S track acquisition.	OT&E	FT	4.3.1	Live Flt #1
309.0	3.7.1	If the MSP bit (bit 25 in the extended capability register) is set (indicating MSP avionics support), TIS shall set a flag asking the sensor to obtain the contents of the transponder MSP capability register (GICB register 29) to check whether the aircraft is requesting TIS service. If this flag is set, the sensor shall request this register before requesting ground-initiated Comm-Bs.	OT&E	FT	4.3.1	Live Flt # 1
309.5	3.7.1	If the flag is set, the sensor shall request this register via a ground-initiated Comm-Bs.	OT&E	FT	4.3.1	Live Flt # 1
310.0	3.7.1	If the TIS request bit (bit 2) of the MSP capability register is set then the TRACK.tis_req_flag shall be set TRUE upon Mode S track acquisition.	OT&E	FT	4.3.1	Live Flt # 1
311.0	3.7.1	If the TIS request bit (bit 2) of the MSP capability register is set, a message containing the aircraft's Mode S address and the tis_req flag value shall be sent to Data Extraction.	OT&E	FT	4.3.1	Live Flt # 1
312.0	3.7.1	If the MSP bit in the extended capability register is not set, or if the TIS request bit in	OT&E	FT	4.3.1	Live Flt # 1

Req. #	Spec Para	Requirement Text	Test Phase	Verification Method	Test Report Verification Paragraph	Test Scenario or Live Flight
		the MSP capability register was not set, then TRACK.tis_req_flag shall be set FALSE upon Mode S track acquisition, and TIS shall not be provided to that aircraft.				
313.0	3.7.2	If the sensor receives a broadcast downlink message, it will check if the message is a TIS Mode S-Specific Protocol message, containing either a TIS Service Connect Request (TSCR) or a TIS Service Disconnect Request (TSDR).	OT&E	FT	4.3.1	Live Flt # 1
314.0	3.7.2	To determine if the broadcast downlink message is a TSCR or a TSDR, the sensor shall first examine the first 8 bits to see that the value is 02 hexadecimal, which value identifies the TIS TSCR and TSDR Comm B messages.	OT&E	FT	4.3.1	Live Flt # 1
315.0	3.7.2	Eight-bit Application Identifier Numbers (AINj, j=1 to 6) shall then be read from the TIS Comm B message (TSCR or TSDR) until either: a) AINj = 0 b) All 56 bits of the downlink message have been processed	OT&E	FT	4.3.2	Live Flt #2
316.0	3.7.2	A request for TIS service (TSCR) shall be identified by an AIN value of 1.	OT&E	FT	4.3.2	Live Flt # 2
317.0	3.7.2	A request to terminate TIS service (TSDR) shall be identified by an AIN value of 2.	OT&E	FT	4.3.2	Live Flt # 2
318.0	3.7.2	If the downlink is a TSCR, then the TRACK.tis_req_flag shall be set TRUE.	OT&E	FT	4.3.2	Live Flt # 2
319.0	3.7.2	A message shall be sent to Data Extraction containing the aircraft's Mode S address and the value of TRACK.tis_req_flag.	OT&E	FT	4.3.2	Live Flt # 2
320.0	3.7.2	If the downlink is a TSDR, then the TRACK.tis_req_flag shall be set FALSE.	OT&E	FT	4.3.2	Live Flt # 2
321.0	3.7.2	Receipt of a TSDR downlink shall cause a message containing the aircraft's Mode S address and the value FALSE to be sent to Data Extraction indicating that TIS service is being discontinued to the aircraft being processed. If the SAP to enable TIS is set, the first interrogation to an aircraft to an aircraft on each scan shall not include any Comm-A message.	OT&E	FT	4.3.2	Live Flt # 2
321.5	3.7.2	If the SAP to enable TIS is set, the first interrogation to an aircraft on each scan shall not include any Comm-A message.	OT&E	FT	4.3.2	Live Flt # 2
322.0	3.8	Both the TIS tracker task and the alert generation task shall perform self-check processes whose results shall be passed to the sensor performance monitor function.	DT&E	CI	4.1	N/A
323.0	3.8	The tracker task shall monitor the position and velocity of CPME tracks.	DT&E	CI	4.1	N/A
324.0	3.8	The alert generation task shall monitor the time delay in generating the appropriate track messages.	DT&E	CI	4.1	N/A

Req. #	Spec Para	Requirement Text	Test Phase	Verification Method	Test Report Verification Paragraph	Test Scenario or Live Flight
325.0	3.8.1	Performance monitor checks shall be performed in the TIS tracker task each time a CPME track is processed.	DT&E	CI	4.1	N/A
326.0	3.8.1	The x and y track positions (both internal XPI/YPI and external XPE/YPE) shall be checked against the CPME Xpos and Ypos values using the respective tolerance value Xerr or Yerr.	DT&E	CI	4.1	N/A
327.0	3.8.1	The CPME track altitude shall also be checked.	DT&E	CI	4.1	N/A
328.0	3.8.1	If any of the position tests show a CPME positional difference exceeding the tolerance (indicating a failure in the TIS horizontal or vertical tracker), then a yellow condition shall be generated.	DT&E	CI	4.1	N/A
329.0	3.8.1	All the CPME track velocity values (internal XDI/YDI, external XDE/YDE, and vertical ZD) shall be checked against the velocity tolerance Verr.	DT&E	CI	4.1	N/A
330.0	3.8.1	If any of the velocity tests show a CPME velocity exceeding the tolerance, then a yellow condition shall be generated.	DT&E	CI	4.1	N/A
331.0	3.8.1	The CPME tracking error yellow condition shall be maintained until a sensor restart.	DT&E	CI	4.1	N/A
332.0	3.8.2	A timing test shall be done in the alert generation task to monitor performance for the task.	DT&E	CI	4.1	N/A
333.0	3.8.2	Each time any alerts or other TIS messages are generated for a given TIS track, the difference between the current time and most-recent report time for the track being processed shall be calculated.	DT&E	CI	4.1	N/A
334.0	3.8.2	If the TIS message time difference is greater than 3/4 of a scan (indicating that the alert generation task is too far behind the TIS tracker task), then a yellow condition shall be generated.	DT&E	CI	4.1	N/A
335.0	3.8.2	The timing performance yellow condition shall be maintained until the time difference becomes less than 3/4 scan again.	DT&E	CI	4.1	N/A
336.0	3.8.2	A second timing test shall be done for each mature track that is requesting TIS service.	DT&E	CI	4.1	N/A
337.0	3.8.2	Each mature track requesting service must receive either traffic data or keep-alive uplink messages at least every 60 seconds.	OT&E	SD	4.2.11	TISHODS8
338.0	3.8.2	If the uplink frequency timing test fails for any qualified track, then a yellow condition shall be generated.	DT&E	CI	4.1	N/A

Req. #	Spec Para	Requirement Text	Test Phase	Verification Method	Test Report Verification Paragraph	Test Scenario or Live Flight
339.0	3.8.2	The uplink frequency yellow condition shall be maintained until the uplink frequency test passes for a subsequent qualified track.	DT&E	CI	4.1	N/A
340.0	3.8.3	TIS restart processing shall re-initialize all the TIS data structures (including the track file, sector lists, sort bins, and local SAP copies).	DT&E	CI	4.1	N/A
341.0	3.8.3	On restart, the TIS tracker task shall be left waiting for surveillance input from its mailbox.	DT&E	CI	4.1	N/A
342.0	3.8.3	On restart, the TIS alert generation task shall be left waiting for its sector time interrupt.	DT&E	CI	4.1	N/A
343.0	3.8.3	If the restart was the result of a sensor channel switch or a recovery, then the track file shall be initialized to force the generation of goodbye messages to all TIS-requesting aircraft.	OT&E	FT	4.3.1	Live Flt # 1
344.0	3.8.3	On restart, all TIS performance monitor yellow conditions shall be reset.	DT&E	CI	4.1	N/A
345.0	3.9	The new data extraction categories described below shall be implemented for TIS: a) TIS reports that are used as input to update the TIS track file. b) The TIS track file entry that is updated by the tracking task. c) TIS alerts/messages that are uplinked to a TIS requesting plane. d) Requests to initiate TIS service via TSCR downlinks e) Requests to terminate TIS service via TSDR downlinks f) Acquisition of an aircraft requesting TIS service via the readout of transponder GICB registers	OT&E	FT	4.3.1	Live Flt # 1
346.0	3.9	The TIS alerts/message category shall include the track entries for the client and intruder tracks.	OT&E	SD	4.2.11	TISHODS8
347.0	3.9	Data extraction shall be performed in the TIS tracker task, in the alert generation task, and in the service request/cancel handler.	OT&E	SD	4.2.10	TISHODS5
348.0	3.10	The TIS categories that are data extracted shall be data reduced through the existing program support facility (PSF) data reduction software.	OT&E	SD	4.2.10	TISHODS5
349.0	1.0	A set of 18 flight scenarios to be used in testing the TIS sensor implementation for performance accuracy.	OT&E	NT		TISCRCL4, TISCRCL8, TISCRDS4, TISCRDS8, TISCRLL4, TISCRLL8,

Req. #	Spec Para	Requirement Text	Test Phase	Verification Method	Test Report Verification Paragraph	Test Scenario or Live Flight
						TISHOCL4, TISHOCL8, TISHODS5, TISHODS8, TISHOLL4, TISHOLL8, TISOTCL4, TISOTCL8, TISOTDS4, TISOTDS8, TISOTLL4, TISOTLL8
349.2	1.0	The 18 scenarios shall be used to assess end-to-end performance of TIS.	OT&E	NT		
349.5	1.0	Test scenarios that result in "incorrect" TIS performance shall be categorized as either "due to TIS deficiencies" or "due to surveillance deficiencies".	OT&E	NT		
349.8	1.0	TIS "incorrect" results that are the result of "surveillance" deficiencies shall be seperately reported as TIS limitations.	OT&E	NT		
350.0	1.0	Each scenario shall involve two aircraft: the TIS-equipped aircraft and an intruder aircraft.	OT&E	NT		
351.0	1.0	In all the scenarios, the TIS-equipped aircraft shall be flying straight north (i.e. 0 degrees azimuth) at a constant speed of 120 knots and at a constant altitude of 5000 feet.	OT&E	NT		
352.0	1.0	The starting azimuth for the TIS-equipped aircraft in each scenario shall be due-east of the sensor (i.e. 90 degrees).	OT&E	NT		
353.0	1.0	The intruder aircraft shall fly at a constant speed of 150 knots.	OT&E	NT		
354.0	1.0	Each scenario shall incorporate sufficient time at the start of each simulated "flight" to establish TIS tracks before the actual encounter begins.	OT&E	NT		
355.0	2.0	The performance of the TIS sensor implementation shall be measured by comparing the displayed TIS intruder aircraft relative position (as determined from the TIS traffic uplink messages generated) against a "truth" relative intruder position.	OT&E	SD	4.2.2 thru 4.2.19 (inclusive)	See Req 349.0
356.0	2.0	The "truth" position shall be computed as the relative position of the intruder aircraft on the scan when the TIS traffic uplink message would be received by the TIS-equipped aircraft -- i.e. one scan later than the uplink was generated.	OT&E	SD	4.2.2 thru 4.2.19 (inclusive)	See Req 349.0

Req. #	Spec Para	Requirement Text	Test Phase	Verification Method	Test Report Verification Paragraph	Test Scenario or Live Flight
356.5	2.0	The “truth” proposition shall be computed using the sensor surveillance reports generated for the particular scan on which the evaluation of the TIS uplink is being conducted.	OT&E	SD	4.2.2 thru 4.2.19 (inclusive)	See Req 349.0
357.0	2.0	A determination of the correctness of each TIS traffic uplink message shall be made.	OT&E	SD	4.2.2 thru 4.2.19 (inclusive)	See Req 349.0
358.0	2.0	A TIS traffic uplink message shall be declared "correct" if each of the following conditions is met: a) relative range matches within plus or minus 1 TIS range scale level b) relative bearing matches within plus or minus 1 TIS bearing level (i.e. +/- 6 degrees) c) relative altitude matches within plus or minus 1 TIS altitude level (i.e. +/- 100 feet within +/- 1,000 foot separation) d) alert state (nothing, proximate, traffic alert) is appropriate with the TIS specification of "proximate" and "traffic" e) intruder altitude rate indicated appropriately (i.e. level if intruder level, climbing if the intruder is climbing at greater than 500 feet/minute, descending if the intruder is descending at greater than 500 feet/minute) f) TIS uplinks are consistent with the sensor surveillance reports for the scan under discussion.	OT&E	SD	4.2.2 thru 4.2.19 (inclusive)	See Req 349.0
359.0	2.0	A scenario run shall be declared as "passed" if 90 percent or more of the TIS traffic uplink messages are declared "correct" over the entire scenario.	OT&E	SD	4.2.2 thru 4.2.19 (inclusive)	See Req 349.0
360.0	3.0	There shall be three basic horizontal TIS scenarios in the performance test: "overtaking" (the intruder aircraft approaches the TIS-equipped aircraft from behind), "crossing" (the intruder aircraft crosses the path of the TIS-equipped aircraft from left to right or right to left), and "head-on" (the intruder aircraft approaches the TIS-equipped aircraft from ahead).	OT&E	NT		
361.0	3.0	Each horizontal scenario shall be run twice, once with the starting point of the TIS-equipped aircraft's flight at a range of 8 nautical miles from the sensor, and a second run with the starting point of the TIS-equipped aircraft's flight at a range of 45 nautical miles from the sensor.	OT&E	NT		
362.0	3.0	Each horizontal scenario shall also have three altitude cases.	OT&E	NT		

Req. #	Spec Para	Requirement Text	Test Phase	Verification Method	Test Report Verification Paragraph	Test Scenario or Live Flight
363.0	3.1	In the overtaking scenario, the intruder aircraft shall begin its flight 7.5 nautical miles behind the TIS-equipped aircraft.	OT&E	NT		
364.0	3.1	The intruder aircraft shall fly due north at a constant speed of 150 knots.	OT&E	NT		
365.0	3.1	The scenario shall continue until the intruder aircraft is 7.5 nautical miles ahead of the TIS-equipped aircraft.	OT&E	NT		
366.0	3.2	In the crossing scenario, the intruder aircraft shall begin its flight 7.5 nautical miles west of the path of the TIS-equipped aircraft and 6 nautical miles north of the TIS-equipped aircraft's starting point.	OT&E	NT		
367.0	3.2	The intruder aircraft shall fly due east at a constant speed of 150 knots.	OT&E	NT		
368.0	3.2	The scenario shall continue until the intruder aircraft is 7.5 nautical miles east of the path of the TIS-equipped aircraft.	OT&E	NT		
369.0	3.3	In the head-on scenario, the intruder aircraft shall begin its flight 10 nautical miles due north of the starting point of the TIS-equipped aircraft's position.	OT&E	NT		
370.0	3.3	The intruder aircraft shall fly due south at a constant speed of 150 knots until it is 10 nautical miles south of the TIS-equipped aircraft.	OT&E	NT		
371.0	4.0	Each of the 6 horizontal scenarios shall be repeated for each of three altitude cases: level, climbing, and descending (for a total of 18 test cases).	OT&E	NT		
372.0	4.0	The intruder aircraft climb/descent rate shall be 700 feet/minute.	OT&E	NT		
373.0	4.1	In the level case, the intruder aircraft shall fly level at a constant altitude of 5500 feet throughout the scenario.	OT&E	NT		
374.0	4.2	In the climbing case, the intruder aircraft shall start the scenario flying level at an altitude of 3600 feet.	OT&E	NT		
375.0	4.2	When the range separation between the intruder aircraft and the TIS-equipped aircraft decreases to 5 nautical miles, the intruder aircraft shall begin to climb at a rate of 700 feet per minute.	OT&E	NT		
376.0	4.2	The climb shall continue until the intruder aircraft reaches 6400 feet, at which time the intruder shall level off and continue to fly at a constant altitude of 6400 feet.	OT&E	NT		
377.0	4.3	In the descending case, the intruder aircraft shall start the scenario flying level at an altitude of 6400 feet.	OT&E	NT		

Req. #	Spec Para	Requirement Text	Test Phase	Verification Method	Test Report Verification Paragraph	Test Scenario or Live Flight
378.0	4.3	When the range separation between the intruder aircraft and the TIS-equipped aircraft decreases to 5 nautical miles, the intruder aircraft shall begin to descend at a rate of 700 feet per minute.	OT&E	NT		
379.0	4.3	The descent shall continue until the intruder aircraft reaches 3600 feet, at which time the intruder shall level off and continue to fly at a constant altitude of 3600 feet.	OT&E	NT		

APPENDIX D
TIS ANALYSIS PROGRAM DESCRIPTION

TIS ANALYSIS PROGRAM DESCRIPTION

The TIS Analysis program is one of the analysis programs that comprise the Radar Beacon Analysis tool (RBAT). TIS Analysis provides a comparison of the tracks and alerts generated by the TIS software to those computed by the analysis software using the target data from the Mode S. This analysis ensures that when TIS generates the two types of advisories to the client aircraft, Traffic and Proximity, it is providing accurate information.

NOTE: A Traffic Advisory is for intruders within 0.5 nautical mile (nmi) and 800 feet in altitude of the client and the Proximity Advisory is for intruders within 5 nmi and 1200 feet of the client.

Within this test report the analysis output indicates the comparison of the target tracks for accuracy of the TIS tracking software. The client summary format and uncorrelated message format have been used to show the results of the TIS testing, but the TIS analysis program has additional options which can provide additional information about the client and intruder aircraft if desired.

The **client summary output** contains the following column headings and a brief description of each is included here:

(1) Client - client number in decimal.
(2) Mode S ID - Mode S ID in hexadecimal.
(3) Traffic Advisory Size - sample size for the traffic advisory reliability.
(4) Traffic Advisory Rel - traffic advisory reliability which is the percent of times when a traffic advisory message is determined by the TIS Analysis program that there is a correlating TIS advisory message.
(5) Traffic Advisory Size - sample size for the traffic advisory false alarm rate.
(6) Traffic Advisory FAlrm - traffic advisory false alarm rate which is the percent of times when there is a TIS traffic advisory message and there is no correlating advisory message determined by the TIS Analysis program.
(7) Proximity Advisory Size - sample size for the proximity advisory reliability.
(8) Proximity Advisory Rel - proximity advisory reliability which is the percent of times when a proximity advisory message is determined by the TIS Analysis program that there is a correlating TIS advisory message.
(9) Proximity Advisory Size - sample size for the proximity advisory false alarm rate.
(10) Proximity Advisory FAlrm - proximity advisory false alarm rate which is the percent of times when there is a TIS proximity advisory message and there is no correlating advisory message determined by the TIS Analysis program.
(11) Bearing Reliability Size - sample size for the bearing reliability.
(12) Bear - bearing reliability which is the percent of times the quantized bearing from the TIS advisory message is within five (30°) of the quantized bearing determined by the TIS Analysis program. Note that the bearing is not defined if the quantized range is zero in the TIS advisory message and that the sample size for the bearing reliability may differ from the reliability size given in (11).
(13) Reliability Size - sample size for the range, altitude, altitude rate, heading, and status reliabilities.

(14) Range - range reliability which is the percent of times the quantized range from the TIS advisory message is within one of the quantized range determined by the TIS Analysis program.
(15) Alt - altitude reliability which is the percent of times the quantized relative altitude from the TIS advisory message is within two of the quantized relative altitude determined by the TIS Analysis program.
(16) ARate - altitude rate reliability which is the percent of times the quantized altitude rate from the TIS advisory message is the same as the quantized altitude rate determined by the TIS Analysis program.
(17) Head - heading reliability which is the percent of times the quantized heading from the TIS advisory message is within one of the quantized relative altitude determined by the TIS Analysis program.
(18) Stat - status reliability, which is the percent of times the status from the TIS advisory message is the same as the status, determined by the TIS Analysis program.

The **uncorrelated message and listing output** contains the following column headings and a brief description of each is included here:

(1) Time-Of-Day - client time-of-day in HH:MM:SS.FFF.
(2) Range - client range in nautical miles.
(3) Azmth - client azimuth in degrees.
(4) Alt - client altitude in feet.
(5) Head - client heading as computed by the TIS Analysis program in degrees.
(6) TisHd - client heading as computed by TIS in degrees.
(7) Mds-ID - client Mode S ID in hexadecimal.
(8) SFN - client surveillance file number in decimal.
(9) T - client report type (N= normal, C = coast, and D = drop).
(10) M - client track is mature (T = true, F = false).
(11) ID - intruder ATCRBS ID in octal or Mode S ID in hexadecimal.
(12) SFN - intruder surveillance file number in decimal.